PRELIMINARY ESTIMATE OF SALT AND TRACE ELEMENT LOADING TO THE SAN JOAQUIN RIVER BY EPHEMERAL STREAMS DRAINING THE EASTERN SLOPE OF THE COAST RANGE (DIABLO RANGE)

California Regional Water Quality Control Board
Central Valley Region
3443 Routier Road, Suite A
Sacramento, CA 95827-3098

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The staff involved in the preparation of this report are:

Dennis W. Westcot, Senior Land and Water Use Analyst

Cassandra A. Enos, Assistant Water Resources Specialist

Polly A. Lowry, Associate Engineering Geologist

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EXECUTIVE SUMMARY

The legislature in 1985 directed the State Board and the Regional Boards to identify and evaluate all sources of selenium and other trace elements that may be impacting water quality. A chief focus of this work was the high selenium concentrations found in the San Joaquin River. An assessment of sources showed two with elevated concentrations; agricultural subsurface drains and streams draining the eastern slope of the Coast Range (Diablo Range). Surveys of both sources were conducted. Results of the subsurface drain assessment have been reported elsewhere (Chilcott et al., 1988). The results of the stream assessment are reported here.

The purpose of the survey was to develop a data base to assess the contribution of these natural sources to the loading of boron, molybdenum, selenium and salinity to the San Joaquin River. The study area is a 130-mile length of the Coast Range extending from the Panoche Fan area in the south to Antioch in the north. In this area, 40 watersheds were identified. Water quality monitoring programs were conducted on 24 of the 40 watersheds to characterize these streams. These 24 watersheds represented 83 percent of the study area.

To make a <u>preliminary estimate</u> of the mass loading, the available water quality data was combined with average stream flow data; however, flow data was only available on 8 of the 40 watersheds. The flow data accounted for 45 percent of the drainage study area. Because of insufficient flow data, four methods were used to estimate the ranges of flow that may be seen on the unmeasured watersheds.

Based upon the flow estimations and median water quality concentrations, a preliminary estimate was made of the mass loadings of salt, selenium, molybdenum and boron to the San Joaquin River. These calculations showed selenium mass loading could vary from 260 to 600 lbs per year depending upon the method used to estimate the flow. This estimate is only 3-6 percent of the annual loading discharged by the subsurface agricultural drains, and therefore, is unlikely to be a significant source of the selenium concentrations measured in the San Joaquin River. In addition, an analysis of the existing flow data shows that greater than 75 percent of selenium mass loading is discharged from January to end of March, a period of maximum dilution flows in the San Joaquin River; therefore, selenium discharged from these creeks is not likely to impact San Joaquin River water quality.

Similar low mass loading was found for molybdenum. Molybdenum concentrations found in these streams were, in most instances, less than the concentrations seen in the San Joaquin River.

In contrast, relatively high concentrations of boron and salt were noted in these streams. The most significant estimate of mass loading was for boron where annual load varied from 400,000 to 600,000 lbs depending upon the method used to estimate the flow. This load could impact San Joaquin River water quality at certain times of the year. However, the impact may be minimized because, as for selenium, over 75 percent of the estimated loading occurs from January to end of March, the period with maximum dilution flows in the San Joaquin River.

Because preliminary estimates show that water quality from the streams draining the eastern slope of the Diablo Range has little impact on San Joaquin River water quality, no further water quality monitoring is proposed. The data base and mass loading projections will be used in the Board's evaluation of the timing of subsurface drainage water discharges to minimize impacts on downstream users.

INTRODUCTION

The legislature in 1985 directed the State Board and the Regional Boards to identify and evaluate all sources of selenium and other trace elements that may be impacting water quality. Numerous studies have focused upon the naturally saline-seleniferous soils of the Panoche Fan area of the Western Central San Joaquin Valley. In this area, the introduction of irrigated crop production has mobilized the trace element selenium from the soil. This trace element has moved into the shallow groundwater and is now discharged with agricultural drainage water which results from controlling the rise of the shallow groundwater table. Discharge of selenium tainted drainage water into wetland habitats has adversely impacted waterfowl and other aquatic habitat (RWQCB, 1988). Elevated levels of selenium have occurred in the San Joaquin River. In addition, boron levels common to these soils are being discharged and may limit the use of the San Joaquin River for irrigation purposes.

Coast Range marine sedimentary formations are the parent material of the soils in the Panoche Fan area and affect both stream and ground water quality in that area. These same formations make up a major portion of the Coast Range as far north as Antioch and are the parent material of the irrigated soils on the western side of the San Joaquin River. Several of these irrigated areas experience high water table (drainage) problems, and subsurface drainage has been installed with discharges to the San Joaquin River.

The surveys of the Panoche Fan showed saline-seleniferous soils could contribute significant quantities of selenium, boron and other trace elements to the San Joaquin River. In addition, streams draining the formations in the Coast Range could pick up significant quantities of salt and trace elements as these streams drain the marine sediments. There is, however, little or no data available on the quality of these streams.

To assess the levels of selenium, boron and other trace elements from these two sources, two separate water quality surveys were conducted. To assess the soil and groundwater selenium levels, a survey of the water quality of tile drainage discharges from the Panoche Fan Area in the south to Antioch in the north was conducted. Results of that survey have been reported (Deverel et al., 1984; DWR, 1985; and Chilcott el al., 1988).

A second survey was conducted to determine the water quality of the streams draining the eastern side of the Coastal Range (Diablo Range). The results of this survey are reported here. The purpose of the survey was to develop a data base on the streams to assess whether the quality of water from streams north of the Panoche Fan area may be similar to streams which discharge to the Panoche Fan Area. The assessment will permit a better understanding of the contribution of natural sources to the loading of boron, molybdenum, selenium and salinity to the San Joaquin River. The objectives of the study were to 1.) identify water quality characteristics through a data base, 2.) assess the water quality characteristics to identify areas of concern for groundwater quality and further drainage investigations, and 3.) use the data base, make a preliminary estimate of the mass loadings of salt, selenium, molybdenum, boron and other measured constituents from the streams to the San Joaquin River.

STUDY AREA

The study area comprises the semi-arid mountains of the interior Coast Range extending from Mt. Diablo near the Concord area south to the San Benito Peak area immediately north of Coalinga (Figure 1). This area extends 130 miles and consists of the streams on the eastern slope of the Coast Range (Diablo Range) that flow into the San Joaquin Valley and Delta. There are 40 drainage basins (watersheds) in the study area with each basin characterized by rugged hills and steep stream gradients. The western portion of these watersheds range in elevation from 2,000 to 5,000 feet above sea level with Mt. Diablo at 3,850 and San Benito Peak at 5,248 feet. Along the eastern boundary of the study area, the sediments making up these hills dip steeply beneath the San Joaquin Valley, thus forming an abrupt boundary with the valley floor that virtually lacks transitional foothills (Davis, 1961).

The watersheds flow from west to east with altitude declining as you move eastward. Flow in these streams is highly dependent upon rainfall. Almost no snow falls in this range and does not contribute to the stream flow characteristics. Most all of the streams in the study area are ephemeral with flows highest during the winter rainfall and spring periods. Average annual precipitation for the watersheds decreases as you move southward through the Coast Range. In addition, precipitation in the Coast Range differs greatly with altitude. Higher elevations in a watershed may receive in excess of 20 inches of rainfall per year while the eastern areas may receive less than 10 inches. Vegetation closely follows the precipitation patterns with the higher altitude locations supporting trees and brush while the lower elevations in most all watersheds only support range grasses. A description of each of the 40 watersheds is in Appendix A.

Because of the size and the diversity of conditions over the 130-mile study area, the description and discussion in this report will concentrate on three stream groups: a northern, middle and southern group. The division chosen for each zone is arbitrary but was chosen to reflect major geographical features that form distinct boundaries. The northern stream group extends from the northern study area boundary to the Altamont Pass Area while the boundary between the middle and southern stream groups is the Pacheco Pass area.

A. NORTHERN STREAM GROUP

The northern area is characterized by low rolling foothills; however, the western portion of the area is dominated by Mt. Diablo, which extends to an elevation of 3,850 feet above sea level. The northern stream group extends from the Sand Creek watershed in the north (adjacent to the Delta outflow near Antioch) to the Altamont Pass in the south. The northern group consists of 10 watersheds that cover 148 square miles, although most are small in size. Only two streams in the group, Marsh and Kellogg Creeks, are considered to have significant flow, the largest of which is Marsh Creek. These two streams make up about 40 percent of the area, but are likely to account for as much as 80 percent of the total runoff from this area. Marsh Creek alone represents 80 percent of the flow of these two creeks. A listing of the watersheds and their size is shown in Table 1. A description of each watershed in this group is in Appendix A.

Table 1 - Physical Characteristics of Watersheds Used in the Study

Watershed Number	Watershed Name	Drainage Basin Size (Sq. mi.)	Water Quality Sampling Station
NORTHERN STREAM GROUP			
1	Sand Creek	11	Yes
2	Deer Valley Creek	5	Yes
3	Briones Valley Creek	7.5	No
4	Marsh Creek	42.5	Yes
5	Kellogg Creek	20	Yes
6	Unnamed Creek	5.2	No
7	Brushy Creek	14.6	No
8	Bethany Reservoir Crk Area	12.9	No
9	Mountain House Creek	11.6	Yes
10	Patterson Run Creek	18	No

(Northern Stream Group Total) = 148.4

MIDDLE STREAM GROUP			
11	Corral Hollow Creek	65.2	Yes
12	Deep Gulch Creek	15.8	No
13	Lone Tree Creek	22.6	Yes
14	Hospital Creek	36.2	Yes
15	Arkansas-Martin Creek Area	12	No
16	Ingram Creek	20.4	Yes
17	Mile 33 Creek	1.6	No
18	Kern Creek	6.1	Yes
19	Del Puerto Creek	76.2	Yes
20	Black Gulch Creek	3	Yes

Table 1 - (Continued) Physical Characteristics of Watersheds Used in the Study

Watershed Number	Watershed Name	Drainage Basin Size (Sq. mi.)	Water Quality Sampling Station
21	Unnamed Creek	3.7	No
22	Salado Creek	25.6	Yes
23	Little Salado Creek	9.1	No
24	Crow Creek	28.4	Yes
25	Interfan Creek	4	No
26	Orestimba Creek	141	Yes
27	Bennett Valley Creek	6	Yes
28	Garzas Creek	57.3	Yes
29	Mustang Creek	8.0	No
30	Quinto Creek	31.6	Yes
31	Romero Creek	24.1	Yes

(Middle Stream Group Total) = 597.9

SOUTHERN STREAM GROUP			
32	Los Banos Creek	156	Yes
33	Salt Creek	21.2	No
34	Ortigalita Creek	56.3	Yes
35	Unnamed Creek	12.9	No
36	Laguna Seca Creek	7.1	No
37	Wildcat Canyon Creek	32	No
38	Little Panoche Creek	90	Yes
39	Moreno Gulch-Panoche Hills	70	No
40	Panoche-Silver Creek	275	Yes

(Southern Stream Group Total) = 720

TOTAL 1466.3 Square Mile

B. MIDDLE STREAM GROUP

The middle area is characterized by steep mountains in the west to more rolling foothills in the east. There is no clearly dominant mountain in this area, but the extended nature of the high mountains along the western boundary influence rainfall and runoff characteristics. The middle stream group extends from the Altamont Pass in the north, almost 50 miles to the south to the Pacheco Pass near the town of Los Banos.

This middle stream group consists of 21 watersheds of varying size and characteristics. These watersheds cover almost 600 square miles. Although several of the streams in this group produce significant flow, two of the streams dominate the area because of their size. These two streams, Del Puerto and Orestimba combined have a drainage area in excess of 200 square miles. Two other watersheds, Corral Hollow and Garzas, also represent significant size and flow. Combined, these two cover about 120 square miles. These four watersheds cover over one-half of the area but likely account for over 75 percent of the total runoff from the middle stream group. A listing of the watersheds and their size is shown in Table 1. A description of each watershed in this group is in Appendix. A.

C. SOUTHERN STREAM GROUP

The southern area is of a similar size to the middle area in that it extends for about 55 miles; however, there are only nine watersheds compared with 21 in the middle stream group. The group is characterized by large watersheds; however, because of the decreasing rainfall as you move south, runoff characteristics and vegetation vary significantly from the northern and middle groups. The most dominant mountain in this portion of the study area is San Benito Peak at 5,248 feet above sea level. This peak is the southern boundary of the study area. The area has several other high peaks principally along the western boundary of the study area.

The nine watersheds that make up the southern stream group are dominated by two, the Panoche-Silver Creek and Los Banos Creek watersheds. These two cover over 65 percent of total area in the southern zone. Four watersheds cover over 95 percent of the area; however, each has greatly differing flow characteristics. A listing of the watersheds and their size is shown in Table 1. A description of each watershed in this group is in Appendix A.

GEOLOGY OF STREAMS DRAINING THE EASTERN SLOPE OF THE DIABLO RANGE

The rocks of this 130-mile length of the Diablo Range have been folded and faulted into a broad anticlinal fold (Anderson and Pack, 1915). The axis of the anticline trends northwest with the slope of the east flank decreasing gradually eastward and ending abruptly at the edge of the San Joaquin Valley.

Various geologic formations make up the Diablo Range along their northwest axis. The west to east flow direction means that each stream will pass through several formations. Davis (1961) found that the chemical character of the waters of streams in the Diablo Range is determined chiefly by the lithologic character of the formations exposed in the drainage basins and those that the streams pass through. Each formation, however, will give a different chemical characteristic to the water.

For the purpose of this study, the geology of the east side of the Southern Coast Range between Mount Diablo and San Benito Peak has been divided into five groups as shown in Table 2. From oldest to youngest they are the Franciscan Formation, ultramafic intrusive rocks, Cretaceous marine sedimentary rocks, Tertiary marine sedimentary rocks, and Tertiary and Quaternary continental deposits. These rocks range in age from Late Jurassic to Quaternary. Except for the ultramafic rocks these groups are all composed of sedimentary rocks, and all but one of these are marine in origin. The marine sedimentary rocks are important to this study since selenium is frequently associated with the sulfur-bearing minerals pyrite and gypsum commonly found in these rocks. These five generalized geologic groups follow those used by Davis (1961) in his initial study of the area. The areas of these simplified geologic units in the 40 watershed drainage basins are shown in Table 3. Also included in Table 3 for comparison purposes are the estimates given by Davis (1961). The areas in Table 3, both the present and those of Davis (1961), are estimates, as exact delineation of the areas is not possible because each group is composed of various geologic formations and some watersheds are very small in comparison to the available geologic maps.

The approximate areas covered by the generalized geologic units in the three stream groups are given in Table 4. The northern stream group is composed predominantly of formations of marine sedimentary rocks of the Cretaceous age. The middle and southern stream group also contain significant portions of this unit, but it is shared almost equally in size with the Franciscan Formation. Overall throughout the study area, these two geologic units make up almost 70 percent of area with the remaining area being occupied by marine and continental deposits of both the tertiary and quaternary age (Table 4).

The sedimentary deposits have been folded and faulted significantly since they were deposited, and for the most part, strike northwest-southeast. Dipping steeply to the northeast, the inclination of the deposits is in sharp contrast to that of the nearly flat-lying sediments of the San Joaquin Valley to the east. A description of each of the five generalized geologic groups used to develop Tables 2 and 3 are given below. A more detailed discussion can be found in Davis (1961), California Division of Mines and Geology (1966), Tanji et al., (1986), U.C. Salinity Drainage Task Force (1987) and Briggs (1953).

Franciscan Formation

Jurassic and Cretaceous rocks of the Franciscan Formation form a continuous northwest-southeast belt from about Tracy south to the Panoche Valley. This formation forms the central core of the Southern Coast Range, occupying the westernmost portions of the watersheds in which it occurs. Exposures of the Franciscan occur in only a small portion of one of the five northern watersheds, in more than 50 percent of all but three of the middle watersheds that have a drainage area in excess of 20 square miles, and in less that 50 percent of all but one of the southern stream groups watersheds. These deposits are composed of deep-water sediments and mafic marine volcanic materials. Graywacke sandstone is the prevalent rock type of the Franciscan, with lesser amounts of shale and conglomerate. Chert and limestone occur in thin beds in association with mafic

Table 2 Generalized Geologic Units Found in the Diablo Range of the Coast Range (Davis, 1961).

GENERALIZED GEOLOGIC UNIT	FORMATION AND AGE
Continental deposits of Tertiary and Quaternary Age	Older Alluvium (Recent? and Pleistocene), terrace deposits (Pleistocene), Tulare formation (Pleistocene? and Pliocene), continental deposits of the McKittrick group.
Marine sedimentary rocks of Tertiary Age	San Joaquin, Etchegoin, and Jacalitos formations, (Pliocene); San Pablo formation, Neroly formation, Cierbo sandstone, Santa Margarita sandstone, Temblor formation, Reef Ridge shale, Monterey formation, and Vaqueros sandstone (Miocene); Kreyenhagen shale (Oligocene and Eocene); Domengine sandstone, Avenal sandstone, and Tejon formation (Eocene); Lodo formation (Eocene and Paleocene); and Martinez formation (Paleocene).
Marine sedimentary rocks of Cretaceous Age	Moreno shale (Paleocene? and Upper Cretaceous) and Panoche formation (Upper Cretaceous).
Ultramafic intrusive rock	Serpentine (post-Franciscan)
Franciscan formation	Franciscan formation (Cretaceous and Jurassic), locally includes small bodies of post-Franciscan ultramafic intrusive rocks.

Table 3 - Areas of Generalized Geologic Units Within the Drainage Basins[1/]

Drainage Basin	CREEK NAME	Area, in Percent, Occupied by Indicated Geologic Unit[2/][3/]				
		Franciscan Formation	Ultramafic Intrusive Rocks	Marine Sedimentary Rocks of Cretaceous Age	Marine Sedimentary Rocks of Tertiary Age	Continental Deposits of Tertiary and Quaternary Age
1	Sand Creek	0	0	6	54	40
2	Deer Creek	0	0	11	53	36
3	Briones Creek	0	0	90	0	10
4	Marsh Creek	6	0	77	0	17
5	Kellogg Creek	0	0	81	2	17
6	Unknown	0	0	23	77	0
7	Brushy Creek	0	0	83	17	0
8	Bethany Creek	0	0	100	0	0
9	Mountain House	0	0	78	22	0
10	Patterson Run Ck	0	0	10	10	80
11	Corral Hollow Crk	(59) 52	(0) 0	(3) 8	(3) 7	(38) 33
12	Deep Gulch Creek	0	0	35	12	53
13	Lone Tree Creek	(69) 62	(0) 0	(19) 21	(12) 5	(12) 12
14	Hospital Creek	(81) 77	0	(19) 15	(0) 0	(0) 8
15	Arkansas-Martin	0	0	0	42	58
16	Ingram Creek	(69) 64	(0) 0	(31) 31	(0) 0	(0) 5
17	Mile 33 Creek	0	0	63	0	37
18	Kern Creek	0	0	95	0	5
19	Del Puerto Creek	(67) 63	(6) 0	(24) 34	(3) 0	(0) 3
20	Black Gulch Crk	0	0	65	10	25
21	Unknown	0	(0) 0	14	0	86
22	Salado Creek	(5) 6	(0) 0	(93) 88	(2) 5	(0) 1
23	Little Salado Crk	0	0	49	0	51

Table 3 - (Continued). Areas of Generalized Geologic Units Within the Drainage Basins[1/]

Drainage Basin	CREEK NAME	Area, in Percent, Occupied by Indicated Geologic Unit[2/3/]				
		Franciscan Formation	Ultramafic Intrusive Rocks	Marine Sedimentary Rocks of Cretaceous Age	Marine Sedimentary Rocks of Tertiary Age	Continental Deposits of Tertiary and Quaternary Age
24	Crow Creek	(0) 0	(0) 0	(98) 73	(2) 11	(0) 16
25	Unknown	0	0	0	10	90
26	Orestimba Creek	(74) 58	(2) 0	(24) 33	(0) 5	(0) 4
27	Bennett Valley Crk	0	0	0	67	33
28	Garzas Creek	(51) 52	(0) 0	(49) 44	(0) 5	(0) 0
29	Mustang Creek	0	0	60	0	40
30	Quinto Creek	(35) 37	(0) 0	(65) 55	(0) 0	(0) 8
31	Romero Creek	(51) 51	(0) 0	(49) 35	(0) 0	(0) 14
32	Los Banos Creek	(81)	(0)	(16)	(3)	(0)
33	Salt Creek	(26)	(0)	(55)	(0)	(19)
34	Ortigalita Creek	(43) 36	(0) 0	(33) 33	(0) 0	(24) 31
35	Unknown	0	0	50	20	30
36	Laguna Seca Creek	0	0	80	10	10
37	Wildcat Canyon	0	0	70	5	25
38	Little Panoche Crk	(41) 43	(0) 0	(25) 18	(0) 0	(34) 39
39	Moreno Gulch Crk	0	0	65	0	35
40	Panoche-Silver Ck	(17)	(0)	(26)	(42)	(15)
4/	Cantua Creek	(0)	(13)	(52)	(35)	(0)
4/	Los Gatos Creek	(0)	(6)	(84)	(10)	(0)

1/ Percentages are approximate; areas are determined by planimeter from the most recent geologic maps of California as transcribed to 1:100,000 scale USGS base maps.

2/ Generalized geologic units are those proposed by Davis (1961) as shown in Table 2.

3/ Percentages in parentheses are those given by Davis (1961) in his initial survey of the area.

4/ These drainage basins are immediately south of the study area and are used only for comparison purposes.

volcanic rocks intrusive into the Franciscan Formation. Metamorphic rocks, such as glaucophane schist and actinolite schist, are also found in this formation.

Ultramafic Intrusive Rocks

Cretaceous serpentine and other ultramafic rocks have intruded the Franciscan Formation along faults and as dikes, sills, or plugs. These are often called serpentine because they have been almost completely altered to minerals of the serpentine group. These rocks occur only where the Franciscan Formation is present and occupy much smaller portions of the watersheds in which they occur than does the Franciscan. Although this unit appears in the Coastal Range, it was not found to exist in the present study area to any significant amount. This finding is consistent with that of Davis (1961).

Being composed mainly of magnesium silicates, these rocks are a major source of magnesium in stream waters which drain the watersheds in which they are present.

Table 4 - Approximate Area in Square Miles Covered by the Generalized Geologic Units as Derived from Tables 1 and 3.

STREAM GROUP	Area, in Square Miles, Occupied by Indicated Geologic Unit				
	Franciscan Formation	Ultramafic Intrusive Rock	Marine Sedimentary Rocks of Cretaceous Age	Marine Sedimentary Rocks of Tertiary Age	Continental Deposits of Tertiary and Quaternary Age
NORTHERN	0	0	95.1	20.2	33.1
MIDDLE	278.1	0	212.8	30.6	76.4
SOUTHERN	237.6	0	223.4	124.7	134.8
TOTAL	**515.7** **35%**	**0** **0%**	**531.3** **36%**	**175.5** **12%**	**244.3** **17%**

Cretaceous Marine Sedimentary Rocks

Upper Cretaceous marine sedimentary deposits of the Panoche and Moreno Formation are in fault contact with the Franciscan Formation and are exposed to the east of that formation. These sediments form a nearly continuous belt along the entire length of the study area, occupying a significant portion of many of the watersheds. The older of these two formations, the Panoche Formation, is mainly composed of shale and sandy shale, sandstone, and some conglomerate and limestone. The Moreno Formation overlies the Panoche Formation and is composed of clastic clay, shale, organic siliceous shale, diatomite, sandstone, and conglomerate. North of the Pacheco Pass, the Moreno Formation is more similar to the Panoche Formation, containing less organic material in that area.

Recent studies have shown that the Moreno Formation is a source of selenium in the Ortigalita Creek and Cantua Creek drainage basins. Selenium is likely associated with the pyrite which is disseminated throughout Coast Range marine sediments. Selenium in addition to being found in pyrite, it is also found in efforescent salt crusts found on the shales of the Moreno Formation. These shales are enriched in the very soluble selenite form of selenium (Presser et al, 1990 and UC Salinity Drainage Task Force, 1987).

Tertiary Marine Sedimentary Rocks

Marine sedimentary rocks of Tertiary age outcrop in a narrow, discontinuous belt along the entire length of the study area. Where exposed, these deposits border either the Franciscan Formation or the Cretaceous marine sedimentary rocks on their east side, sometimes forming the eastern boundary of the Coast Range foothills. Except for many of the smaller watersheds (<20 square miles) and the Panoche and Silver Creek watersheds, Tertiary marine sedimentary rocks are either not exposed at all within, or form only a minor portion of, the remaining watersheds.

Seventeen different formations make up the Tertiary marine sedimentary rocks which range in age from Paleocene to Pliocene. These deposits are similar in many respects to the Cretaceous marine sedimentary rocks. Arkosic sandstone, mudstone, calcareous shale, conglomerate, silt and clay deposits make up these formations. Siliceous rocks and organic shales are also common. Black iron sulfide has been observed in the siliceous rocks and is likely also associated with organic matter.

In some areas the distinctive organic, siliceous sediments of the Kreyenhagen Shale make up half of the early Tertiary deposits. In the Ortigalita Creek and Cantua Creek watersheds, the Kreyenhagen Shale has been shown to have significant levels of selenium, even higher than those found in the Moreno Formations. In the area of this study, the Kreyenhagen also outcrops in the Crow Creek, Orestimba Creek, and Garzas Creek watersheds. In the latter two watersheds, it makes up a very small percentage of the total area while in the Crow Creek Watershed, it makes up a significant portion of the watershed.

Continental Deposits of Tertiary and Quaternary Age

Continental deposits of Tertiary and Quaternary age occur along the eastern flank of the Coast Ranges, occupying some portions of the watersheds in the northern and southern stream groups. In the middle stream group, these deposits are exposed only in the Pacheco Pass Area.

These deposits consist of poorly-sorted silt which enclose lenses of poorly-sorted sand and gravel. Locally, limy or marly beds, reworked gypsum, and bedded gypsum are present.

HYDROLOGY OF STREAMS DRAINING THE EASTERN SLOPE OF THE DIABLO RANGE

The hydrology of each watershed varies depending upon rainfall and elevation. Larger watersheds with significant areas of higher elevation produce more streamflow yield per square mile of drainage area than lower-elevation and small watersheds. Watersheds in the northern stream group are likely to encounter more frequent storms than watersheds further south thus influencing the rainfall amounts and runoff characteristics.

Annual rainfall also varies throughout the study area. More frequent and heavier storms occur in the north. For a given elevation, rainfall will be higher in the north decreasing as you proceed 130 miles to the southernmost watershed. In addition, a decreasing rainfall pattern occurs from west to east in each of the individual watersheds. The eastern slope of the Diablo Range is typical of a mountainous-rainshadow drainage basin.

Data on streamflow characteristics for the individual watersheds is very limited. Table 5 lists the available data on streamflow for the portion of the Diablo Range covered in this study. In the northern stream group records are available for only 2 of the 10 streams; Marsh and Kellogg Creeks. The data on Marsh Creek is measured flow while the data for Kellogg Creek is a simulated flow by the Los Vaqueros Dam Project. Marsh Creek streamflow originates in the higher elevation areas of Mt. Diablo while Kellogg Creek is a medium-elevation creek.

In the middle stream group records are available for 3 of the 21 streams; Corral Hollow, Del Puerto and Orestimba Creeks. The drainage area of these three creeks covers about 50 percent of the total area of the middle group. All three drainage basins have their headwaters in high altitude areas. These three watersheds drain the entire western portion of the middle stream group and should give a good understanding of flow characteristics in these streams.

Data is scarce in the southern area. None of the watersheds have a long-term record. Panoche Creek has an 12-year record, but this period is not adequate to make reliable projections. More reliable projections can be made using Los Banos Creek and Little Panoche Creek where the California Department of Water Resources has made flow estimates based upon the change in storage that occurred in the Retention Reservoir on these creeks. Water Resources staff place a good reliability in the flow estimates for Los Banos Creek, but only place a fair reliability on the estimates for Little Panoche Creek (Department of Water Resources, pers comm.). Because of the lack of reliable data, flow records for Cantua Creek and Los Gatos Creek were included in this study. Both watersheds are in the eastern slope of the Diablo Range and lie immediately south of the Panoche Creek watershed. Both streams are gauged and have very reliable records.

Stream flows in all of the watersheds are strongly influenced by winter rainfall periods. Where data is available, strong fluctuations are seen between the maximum and minimum flows in the creeks. Maximum flow rates, as shown in Table 6, occur only in the winter rainfall periods while there are many days, especially in late summer or dry years when there is no flow being recorded.

Table 5 - Streamflow Records for Streams Draining the Eastern Slope of the Coast Range (Diablo Range).

Watershed Number	STREAMS	Year of Record	DWR Station Number	USGS Station Number
4	Marsh Creek (near Byron)	1953 - 1983	B8 - 9100	113375.00
5	Kellogg Creek (near Byron)	1921 - present[1/]	B9 - 5295	-
11	Corral Hollow Creek (near Tracy)	1959 - 1966	B8 - 9500	113040.00
19	Del Puerto Creek (near Patterson)	1958 - present	B8 - 8004	112746.30
26	Orestimba Creek (near Newman)	1932 - present	B8 - 7100	112745.00
32	Los Banos Creek (above Los Banos Reservoir)	1967 - present	2/	
38	Little Panoche Creek (above Little Panoche Reservoir)	1961 - present	2/	
40	Panoche Creek (below Silver Creek, near Panoche)	1959 - 1970	B8 - 1100	112555.00
3/	Cantua Creek (near Cantua Creek)	1967 - present	C7 - 7050	112533.10
3/	Los Gatos Creek (above Nunes Canyon, near Coalinga)	1945 - present		112245.00

1/ Data for Kellogg Creek is a simulated flow by the Los Vaqueros Dam Project (CCWD, 1990) from existing records for the period 1958-1977.

2/ Data for Los Banos Creek and Little Panoche Creek are simulated flows by Department of Water Resources through changes in reservoir storage.

3/ Cantua and Los Gatos Creek watersheds are immediately south of the study area.

For those watersheds with sufficient records, the average annual discharge for the period of record is given in Table 6. The annual discharge varies widely with the type of rainfall year. The maximum and minimum annual discharges for each of the measured watersheds is also given in Table 6. Water year 1983 consistently showed the highest annual flow while various years showed very low flows. The maximum annual discharge was, in most instances, 5-6 times the average annual discharge. This relationship appeared to be consistent throughout the measured watersheds.

The average yield per square mile was determined for each of the measured watersheds. These varied from 190 acre-feet to 9 acre-feet per square mile. The highest yields were found with Marsh and Kellogg Creeks in the northern stream group. Marsh Creek flow is strongly influenced by Mt. Diablo and North Peak which dominate the western portions of the watershed. This high-elevation area covers 40-50 percent of the watershed, a value significantly higher than any other watershed in the study area. The mid-elevation Kellogg Creek watershed shows a yield approximately 50 percent that of Marsh Creek. This influence of altitude is likely consistent throughout the study area. Lower-elevation watersheds may show an even greater difference.

The average yield per square mile for Del Puerto and Orestimba Creeks in the middle stream group were also about 50 percent of the yield for Marsh Creek. Even though both creeks have higher-elevation areas, this difference is likely the result of both a lower percentage of area with higher elevation and the decreasing rainfall amounts as you move south in the study area. The mid- and lower-elevation watersheds in the same area are likely to show a reduction from the yields shown for these two higher-elevation creeks.

Los Banos Creek in the southern stream group demonstrated a yield per square mile similar to that found in the Del Puerto and Orestimba Creeks watersheds in the middle stream group. Los Banos Creek shows many similarities to the creeks in the middle stream group; however, the watershed also represents the area where rainfall begins a significant drop as you move south of this watershed. This change in rainfall patterns is seen in the remainder of watersheds in the southern stream group as yield per square mile drops significantly. Yields for both Cantua and Los Gatos Creek are close to 50 percent of those recorded in the middle stream group. The yield, however, for Panoche-Silver and Little Panoche Creeks are 10-20 percent. These low yields are likely due to a lower percentage of the drainage basin having higher-elevation areas and lower average rainfall for the entire watershed. These yields may represent yield from many of the smaller basins throughout the study area that do not have significant higher-elevation areas.

The average annual flow or yield, as discussed earlier, is not uniform throughout the year. Runoff is strongly associated with periods of significant rainfall. Table 7 shows the percentage of the average annual flow that occurs in each month for the period of record given in Table 6. The reliability of the data in Table 7 varies with the period of record but shows consistent patterns. The percentage of annual flow shown in Table 7 varies between watersheds for each month, however, over 75 percent of the annual flow occurs in the period January to end March. A discussion of the data for each creek is given in Appendix A while for the assessment in this study, the average value for all the creeks will be used.

Table 6 - Annual Streamflow Characteristics for Streams Draining the Eastern Slope of the Coast Range (Diablo Range)

Watershed Number	STREAM	Maximum Flow (cfs)	Minimum Flow (cfs)	Maximum Annual Discharge (AF)	Minimum Annual Discharge (AF)	Average Annual Discharge (AF)	Average Yield AF per Square Mile 1/
4	Marsh Creek (near Byron)	6,000	0	39,940 ('83)	0 ('61,'76,-'77)	8,040	190
5	Kellogg Creek (near Byron)	--	0	9,570 ('83)	10 ('77)	1,875	95
11	Corral Hollow Creek (near Tracy)	--	0	550 ('62)	50 ('61)	2/	2/
19	Del Puerto Creek (near Patterson)	1,800	0	34,560 ('83)	21 ('77)	5,270	73
26	Orestimba Creek (near Newman)	10,200	0	32,646 ('83)	0 ('47-8,'54, '61,'68,'72, '76-7,'88-'90)	12,320	92
32	Los Banos Creek (above Reservoir)	--	0	56,600 ('83)	900 ('77)	12,200	78
38	Little Panoche Crk (above Reservoir)	--	--	9,040 ('83)	9 ('67)	1,435	16
40	Panoche Creek (near Panoche)	--	0	12,020 ('69)	4 ('61)	2,475 2/	9 2/
3/	Cantua Creek (near Cantua Creek)	3,420	0	13,630 ('83)	2.5 ('89)	2,340	50
3/	Los Gatos Creek (above Nunez Canyon, near Coalinga)	4,360	0	35,080 ('83)	0 ('89)	4,050	42

1/ Drainage Basin Area is given in Table 1. Area for Cantua and Los Gatos Creeks are 47 and 96 square miles, respectively.

2/ Data too limited to make a reliable projection.

3/ Cantua and Los Gatos Creek watersheds are immediately south of the study area.

Table 7 - Monthly Streamflow Characteristics for Streams Draining the Eastern Slope of the Coast Range (Diablo Range).

Watershed Number	STREAM	Flow as a Percentage of Annual Flow											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4	Marsh Creek (near Byron)	27.5	24.2	21.3	14.3	2.9	0.6	0.1	0	0	0.2	0.9	8.0
5	Kellogg Creek (near Byron)	28.9	29.4	17.4	9.4	0.9	0	0	0	0	0.5	2.5	11.0
11	Corral Hollow Creek (nr Tracy)	15.7	43.1	21.1	6.1	2.9	0.8	0	0	0	1.4	3.1	4.3
19	Del Puerto Creek (near Patterson)	17.9	29.4	28.3	10.8	4.7	2.3	0.4	0.1	0.1	0.1	1.4	4.5
26	Orestimba Creek (near Newman)	20.2	35.8	23.3	12.0	1.7	0.3	0.1	0	0	0	0.5	6.1
32	Los Banos Creek (above Los Banos Reservoir)	23.4	32.0	23.3	8.9	1.4	0.2	0	0	0.1	0.4	2.6	7.8
38	Little Panoche Creek (above Reservoir)	12.0	28.3	23.0	8.2	4.7	2.6	2.0	1.7	2.0	3.8	5.0	6.0
40	Panoche Creek (near Panoche)	26.0	34.6	21.0	5.7	1.6	0.3	0	0	1.0	0.3	1.4	7.4
1/	Cantua Creek (near Cantua)	15.3	24.8	30.6	12.4	6.8	2.7	1.0	0.2	0.4	0.3	1.2	4.3
1/	Los Gatos Crk (abv Nunez Canyon, near Coalinga)	15.5	32.0	25.3	13.5	3.7	1.2	0.2	0.1	0.4	0.4	1.5	6.2
	Average	**20**	**32**	**24**	**10**	**3**	**1**	**0**	**0**	**0**	**1**	**2**	**7**

1/ Cantua and Los Gatos Creek watersheds are immediately south of the study area.

As discussed earlier, most of the watersheds draining the eastern slope of the Diablo Range are not gauged to record flow. Average annual runoff estimates are needed, however, to make estimates of the mass emissions from each watershed. As data was not available, four different approaches were utilized to make these estimates. It is recognized that all four methods are only first approximations of what may actually occur in the unmeasured watersheds. The four methods were utilized to determine whether there would be large differences or ranges in mass emission estimates. A brief description of each method is given here with the annual flow estimates for each method given in Table 8.

METHOD I. Eight of the creeks in the Diablo Range have flow measurements (Table 6) which include the average annual discharge for the watershed from a given area in square miles (Table 1). From this data an annual average yield per square mile is calculated for each measured stream within the stream study groups. This yield is then applied to the remaining unmeasured watersheds. The results are presented as method I in Table 8. The weakness of this approach is that the measured watersheds are the largest watersheds and each has extensive higher-altitude areas with corresponding higher rainfall. Applying this yield to lower-elevation, unmeasured watersheds could overestimate the average annual flow of these smaller watersheds. As the measured (gauged) watersheds represent only 45 percent of the total area, the error could be significant.

An example of this difference is seen in the northern stream group where the yield for Marsh Creek is approximately twice that found for the mid-elevation watershed Kellogg Creek. An even lower yield may occur in the lower-elevation watersheds.

METHOD II. Method II was developed to emphasize the differences in rainfall patterns. The total precipitation volume on each watershed was estimated from the 50-year average annual rainfall maps. A description of the method used to determine the total rainfall volume in acre-feet is given in Appendix B. The average annual rainfall volume (AF) for the measured watersheds was divided by the average annual discharge (AF) to give a percent yield. The percentage yield for each stream group was then applied to the average annual rainfall volume of the unmeasured streams to give an approximation of the average annual yield. The results for each watershed are presented in Table 8 as Method II. The weakness of this approach is that it applies the rainfall characteristics of the higher-elevation watersheds to the lower-elevation watersheds. Part of this error is accounted for by the differences in average annual rainfall volumes; however, the yield per square mile in the lower-elevation, lower-rainfall pattern basins may be lower and this would not be accounted for by this method. This method could over estimate the flows in smaller watersheds.

An example of this is Kellogg Creek where the average annual runoff is only 55 percent of the yield projected when the runoff factor for Marsh Creek is applied to Kellogg Creek. This error factor may become larger for the southernmost watersheds where rainfall patterns become less intense. The largest error may continue to be higher yield factors for the higher-elevation watersheds being applied to the lower-elevation watersheds.

TABLE 8 - Determination of Average Annual Yield for Watersheds Draining the Eastern Slope of the Diablo Range Within Study Area Using Four Estimation Techniques Described in the Text.

WATER-SHED NUMBER	CREEK NAME	Area[1/] $(mi.)^2$	Gauged Yield (AF/sq.mi.)	Calc. Prec. Volume[2/] (AF)	% Runoff Factor[3/] (Yield)	PPT Volume per sq.mi. (AF/sq.mi.)	Water-shed Factor	METHOD I Yield	METHOD II Yield	METHOD III Yield	METHOD IV Yield
1	SAND CREEK	11.1	190	9,195	0.17	830	0.2	2,109	1,563	1,169	422
2	DEER CREEK	5.1	190	4,080	0.17	800	0.2	969	694	500	194
3	BRIONES CREEK	7.5	190	7,275	0.17	970	0.2	1,425	1,237	1,081	285
4	MARSH CREEK	42.6	190[4/]	47,450	0.17	1,110	1.0	8,040	8,040	8,040	8,040
5	KELLOGG CREEK	20.0	95[4/]	20,195	0.17	1,010	1.0	1,875	1,875	1,875	1,875
6	UNKNOWN	5.2	190	3,590	0.17	690	0.2	988	610	380	198
7	BRUSHY CREEK	14.6	190	10,695	0.17	730	0.2	2,774	1,818	1,196	555
8	BETHANY CREEK	12.9	190	8,915	0.17	690	0.2	2,451	1,516	942	490
9	MOUNTAIN HOUSE CRK	11.6	190	7,275	0.17	630	0.2	2,204	1,237	702	441
10	PATTERSON RUN CREEK	18.0	190	10,145	0.17	565	0.2	3,420	1,725	878	684
11	CORRAL HOLLOW CREEK	65.2	82	42,760	0.105	655	0.6	5,346	4,490	3,586	3,208
12	DEEP GULCH CREEK	15.8	82	7,215	0.105	460	0.2	1,296	758	425	259
13	LONE TREE CREEK	22.6	82	14,105	0.105	625	0.5	1,853	1,481	1,129	927
14	HOSPITAL CREEK	36.2	82	24,110	0.105	665	0.5	2,968	2,532	2,053	1,484
15	ARKANSAS-MARTIN CRK	12.0	82	5,720	0.105	480	0.2	984	601	352	197
16	INGRAM CREEK	20.4	82	11,440	0.105	560	0.5	1,673	1,201	820	836
17	MILE 33 CREEK	1.6	82	845	0.105	530	0.2	131	89	57	26
18	KERN CREEK	6.1	82	3,270	0.105	535	0.2	500	343	224	100
19	DEL PUERTO CREEK	76.2	73[4/]	54,660	0.105	720	1.0	5,270	5,270	5,270	5,270
20	BLACK GULCH CREEK	3.0	82	1,585	0.105	530	0.2	246	166	108	49
21	UNKNOWN	3.7	82	1,995	0.105	540	0.2	303	209	138	61

TABLE 8 - (Continued) Determination of Average Annual Yield for Watersheds Draining the Eastern Slope of the Diablo Range Within Study Area Using Four Estimation Techniques Described in the Text.

WATER-SHED NUMBER	CREEK NAME	Area[1/] $(mi)^2$	Gauged Yield (AF/sq.mi.)	Calc. Prec. Volume[2/] (AF)	% Runoff Factor[3/] (Yield)	PPT Volume per sq.mi. (AF/sq.mi.)	Water-shed Factor	METHOD I Yield	METHOD II Yield	METHOD III Yield	METHOD IV Yield
22	SALADO CREEK	25.6	82	15,760	0.105	615	0.5	2,099	1,655	1,241	1,050
23	LITTLE SALADO CREEK	9.1	82	5,455	0.105	600	0.2	746	573	419	149
24	CROW CREEK	28.4	82	17,550	0.105	620	0.5	2,329	1,843	1,393	1,164
25	UNKNOWN	4.0	82	1,810	0.105	455	0.2	328	190	105	66
26	ORESTIMBA CREEK	141.0	92[4/]	115,720	0.105	820	1.0	12,320	12,320	12,320	12,320
27	BENNETT CREEK	6.0	82	3,200	0.105	535	0.2	492	336	219	98
28	GARZAS CREEK	57.3	82	42,745	0.105	745	0.8	4,699	4,488	4,078	3,759
29	MUSTANG CREEK	8.0	82	4,290	0.105	535	0.2	656	450	294	131
30	QUINTO CREEK	31.6	82	20,825	0.105	660	0.5	2,591	2,187	1,760	1,296
31	ROMERO CREEK	24.1	82	15,665	0.105	650	0.5	1,976	1,645	1,304	988
32	LOS BANOS CREEK	156.0	78[4/]	126,085	0.097	810	1.0	12,200	12,200	12,200	12,200
33	SALT CREEK	21.2	9	9,610	0.03	455	0.2	191	288	162	38
34	ORTIGALITA CREEK	56.3	27	31,875	0.03	565	0.4	1,520	956	667	608
35	UNKNOWN	12.9	9	5,505	0.02	430	0.2	116	110	58	23
36	LAGUNA SECA CREEK	7.1	9	3,180	0.02	450	0.2	64	64	35	13
37	WILDCAT CANYON CRK	32.0	9	13,670	0.02	430	0.2	288	273	145	58
38	LITTLE PANOCHE CRK	90.0	27	50,730	0.03	565	0.4	2,430	1,522	1,062	972
39	MORENO GULCH CREEK	70.0	9	30,500	0.02	435	0.2	630	610	328	126
40	PANOCHE-SILVER CRK	275.0	9[4/]	202,515	0.02	735	1.0	2,475	2,475	2,475	2,475
	TOTAL AREA	1,467				**TOTAL YIELD**		95,000	81,600	71,100	63,100

1/ Area as given in Table 1
2/ A description of the method used to determine the total rainfall volume in acre-feet is given in Appendix B.
3/ Percent runoff factor is determined from watersheds with measured flow as compared to the calculated precipitation volume as described as Appendix B.
4/ Actual measured yield (Table 6)

METHOD III. To account for differences in the average annual rainfall volume per square mile, Method III was developed. This method modifies the results of Method II. An adjusted yield is then determined by:

$$\text{Yields (AF)} = \frac{\text{Precipitation Volume (AF/mi}^2\text{) (Unmeasured Creek)}}{\text{Precipitation Volume (AF/mi}^2\text{) (Measured Creek)}} \bullet \text{Yield (AF) Method II}$$

This method is an improvement on Method II, but still is dependent upon the accuracy of the average annual precipitation data used to calculate the precipitation volume. The method does not account for expected water use in the drainage basin which may limit actual water yield. In the lower-elevation, lower-rainfall watersheds, the percentage of rainfall that is utilized by plants will be higher than in many of the larger measured watersheds.

METHOD IV. Accounting for differences in vegetation usage would require extensive use of climate and evapotranspiration data which is beyond the scope of this study. To estimate differences in watersheds, arbitrary yield reductions were assigned to the unmeasured watersheds. The method involves utilizing the yield per square mile of watershed as determined by Method I and multiplying it by a factor for the watershed size. Watershed size reflects elevations and rainfall patterns as the largest watersheds contain high rainfall-high altitude areas and vice versa. The factors utilized in this study were:

Square miles	Factor
Measured Creeks	1.0
>50	0.4 - 0.8[1/]
20 - 50	0.5[2/]
<20	0.2

[1/] Factor was decreased based on watershed location. Those further south had lower factors.

[2/] Those watersheds which contained a number of smaller creeks were considered as a creek with <20 square miles.

The weakness of this method is that it assigns a factor to describe watershed size, but there is no data to show whether these factors reflect field conditions. Thus the factors become professional judgments, however, these yield may more accurately reflect flow in the lower-elevation watersheds which yield only during significant storm periods.

The average annual yield calculated by the four methods varies from 95,000 (Method I) to 63,100 (Method IV) acre-feet per year. The measured watersheds, which represent approximately 48 percent of the study area, represented a low of 44 percent of the total annual flow estimated using Method I to 67 percent when calculated using the more conservative Method IV. These estimated yields were used to calculate the total annual load discharged from the study area.

WATER QUALITY OF STREAMS DRAINING THE EASTERN SLOPE OF THE DIABLO RANGE

There is very little data on the chemical quality of the streams draining the eastern slope of the Diablo Range. Davis (1961) has done the most extensive survey of these streams. He concludes that the quality of these streams differs greatly despite similarities of climate and precipitation over the various watersheds. Davis feels that the chemical quality of the streams is determined by the lithologic character of the rocks exposed in the drainage basins rather than climate and rainfall.

Streams in the study area are made up of varying proportions of direct runoff and ground-water discharge. At high flow much of the discharge consists of direct runoff while after rainfall the discharge consists chiefly of ground-water discharge. This ground-water discharge has had a greater opportunity to react with the soil and underlying rocks. Davis (1961) showed that concentration was inversely related to the discharge rate. Interestingly, even though he found that discharge and concentration were inversely related, the chemical character of the individual stream rarely changed indicating the strong influence of rocks and geologic formations that the water passes through and over.

The median cation and anion concentrations were used to illustrate the chemical character of the water in the creeks sampled in this study. The data are presented in Figure 2 which is the diagram described by Piper (1945). The Piper diagram is useful to see the dominant anion and cations as the percentage of the total equivalents per million (percentage reacting values). The principal constituents of the water are plotted on the diagram. Davis (1961) found there were few differences in the proportions of cations in stream waters draining the eastern slope of the Diablo Range. Most of the streams sampled in this study showed no strongly dominant cation. The exception being Salt Creek (#33) which showed a strong sodium-type water. Six other creeks showed as sodium types, but none showed as strong a dominance as Salt Creek. Del Puerto and Black Gulch Creeks showed a magnesium-type water, a finding consistent with Davis (1961).

There did not appear to be a single dominant anion for all the creeks, but most showed a strong dominance for one anion or the other. The greatest number of creeks showed a strong sulfate dominance. Almost all of the creeks showing this strong sulfate dominance were small or mid-sized creeks (<30 square miles). In contrast, the largest five watersheds (Table 1) showed no dominant anion type. Very few creeks showed a bicarbonate or a chloride-type anion dominance.

An excellent discussion of the mineral characteristics of several of these streams is given in Davis (1961). Davis attempted to relate the geochemistry of the various geologic formations to the mineral character of these streams. The purpose of this report is not to continue this discussion on geologic control of water quality but to carry the Davis work further to estimate the loads carried by these streams. In addition, the present study goes beyond the mineral quality studied by Davis in order to identify streams that may be contributing significant quantities of trace elements to the San Joaquin River. Emphasis for load estimations will be on three trace elements, boron, molybdenum and selenium while spot checks of other trace elements were also made.

To determine the chemical character of the water of typical streams that flow into the San Joaquin River and Delta from the semi-arid eastern slope of the Diablo Range, water quality samples were collected on a periodic basis from

December 1985 to March 1988. Sampling was stopped in March 1988 as the streams were beginning to show the impact of the second dry year and additional water quality samples may not be representative. Sampling was not resumed as drought years continued through the 1990 water year. In addition, water quality samples collected by the California Department of Water Resources and the United States Geological Survey were used in the data analysis when data was available.

Monitoring periods were established to sample the streams during low-flow periods with occasional samples taken during significant high-flow storm periods. This emphasis on the low-flow period allowed a comparison with the work of Davis (1961). In the Davis study, sampling was done only during low-flow periods which was defined as flow of less than 0.15 cubic feet per second per square mile of tributary drainage basin. Flows higher than this level are only likely to be encountered during intense storm periods and these were infrequent during the sampling period for this study. During this study, sampling was also not conducted during very low-flow periods to avoid sample results that may reflect significant evapoconcentration.

Water quality samples were collected from or were available for 24 of the 40 watersheds in the study area. Constituent concentrations varied between watersheds, time of the year and between years. Median mineral concentrations for the 24 watersheds are shown in Table 9 along with the median trace element concentrations. The data in Table 9 represents sampling done in this study between December 1985 to March 1988 as well as data available on these creeks from other agencies. Data for the individual streams and actual sampling dates are given in Appendix A. The data in Appendix A is presented along with the discussion of each individual watershed and is arranged by watershed beginning in the north and proceeding south (Table 1). In addition to the water quality data collected in this study, the water quality data of Davis (1961) and others are included in the listings found in Appendix A. Also included in the Appendix is a sampling site description. The discussion that follows will look at the differences between the 24 creeks that were monitored in addition to a description of the differences between the 3 stream groups as shown in Table 1.

Salinity concentrations varied by watershed drainage basin (Table 9). The variability appeared to be greatest between basins of different size. The lowest salinity appeared in the largest basins with salinity increasing as the basin size decreases. This inverse relationship was least pronounced in the southern study zone, south of Los Banos Creek. This lack of difference is probably related to lower rainfall totals and the higher salinity levels found in the native soil materials.

Boron concentrations were not directly related to the salinity concentrations. The northern study zone is a known boron enriched area and stream quality in this area reflects this. Boron is strongly elevated in almost all watersheds north of Del Puerto Creek with especially high boron being noted in the Contra Costa County area of the northern stream group. The average of the median concentrations for the 18 creeks north of Del Puerto Creek is 4.5 mg/L boron, while the average for the 14 creeks in the zone from Del Puerto Creek in the north to the southern end of the Los Banos drainage basin is 1.5 mg/L. The region south of Los Banos Creek is strongly enriched with boron. The limited data base shows a 13 mg/L average for the median values for the 8 creeks in this southern area.

Table 9 - Median Salinity, Boron, Selenium and Molybdenum Determined from Available Data Bases for Streams Draining the Eastern Slope of the Diablo Range of the Coast Range Mountains[1/]

Watershed Number	CREEK	MEDIAN VALUE			
		Salinity (μmhos/cm)	Boron (mg/L)	Selenium (μg/L)	Molybdenum (μg/L)
NORTHERN STREAM GROUP					
1	Sand Creek	3,000	4.1	3.9	9.0
2	Deer Creek	4,950	1.1	3.3	3.0
4	Marsh Creek	1,200	3.0	1.0	<5
5	Kellogg Creek	1,800	6.4	3.3	--
7	Brushy Creek	1,100	2.6	--	--
9	Mountain House Creek	3,775	8.1	9.3	--
MIDDLE STREAM GROUP					
11	Corral Hollow Creek	2,000	4.7	1.0	<5
13	Lone Tree Creek	1,475	2.9	1.7	--
14	Hospital Creek	855	0.94	1.0	<5
16	Ingram Creek	2,000	6.0	4.3	<5
18	Kern Creek	5,750	10	6.5	--
19	Del Puerto Creek	1,350	1.6	0.6	<5
20	Black Gulch Creek	8,500	4.5	20	11
22	Salado Creek	2,600	1.6	3.9	<5
24	Crow Creek	4,800	2.2	8.0	<5
26	Orestimba Creek	750	0.32	1.0	<5
28	Garzas Creek	740	0.40	<1	<5

Table 9 - (Continued) Median Salinity, Boron, Selenium and Molybdenum Determined from Available Data Bases for Streams Draining the Eastern Slope of the Diablo Range of the Coast Range Mountains[1/]

Watershed Number	CREEK	MEDIAN VALUE			
		Salinity (μmhos/cm)	Boron (mg/L)	Selenium (μg/L)	Molybdenum (μg/L)
SOUTHERN STREAM GROUP					
30	Quinto Creek	940	1.1	<1	<5
31	Romero Creek	1,000	1.7	<1	<5
32	Los Banos Creek	550	0.28	<1	<5
33	Salt Creek	8,800	25	--	--
34	Ortigalita Creek	5,700	5.7	5.0	<5
38	Little Panoche Ck (above Reservoir)	1,700	6.4	0.5	<5
38	Little Panoche Ck (below Reservoir)	3,300	13	0.5	1
40	Panoche-Silver Creek	9,250	12	3	8
40	Silver Creek	7,650	11	7.5	9.6
--	Cantua Creek	1,500	0.78	--	--
--	Los Gatos Creek	1,410	0.89	--	--

1/ Data Bases used to develop this Table are presented in Appendix A.

While boron is widespread in the study area, molybdenum is not strongly elevated. Only in the northernmost and southernmost drainage basins is molybdenum elevated. In most instances, the median concentrations were less than 5 μg/L. Median concentrations being measured in the San Joaquin River are also below this level.

Selenium concentrations were less predictable and are probably related to the geology of the formations the creek passes through. Those drainage basins which showed median selenium concentrations in excess of 2.0 μg/L showed a significant portion of the watershed area occupied by marine sedimentary rocks of both the Cretaceous and Tertiary Age (Table 3 and Table 9). Median selenium concentrations ranged from 0.5 to 20 μg/L with the highest median concentrations being found in small to mid-sized drainage basins. Of the eleven creeks with a drainage basin area greater than 30 square miles, only 2 showed median total recoverable selenium concentrations greater than 1.0 μg/L. These two creeks were Ortigalita and Panoche-Silver Creek whose median values were 5.0 and 3.0 μg/L, respectively (Table 9). Both these creeks are in the southern stream group. None of creeks with a drainage basin area greater than 30 square miles and north of Ortigalita Creek showed a median concentration greater than 1.0 μg/L.

The salinity and trace element concentrations were used to calculate the mass load from each drainage basin (See next section).

MASS LOADING

One of the three objectives of this study was to utilize the flow and water quality data bases to make a preliminary estimate of the mass loading of salt, boron, selenium and molybdenum that would be discharged to the San Joaquin River from the creeks draining the eastern slope of the Diablo Range. Where possible, estimates will be made of the timing of this discharge and the relative importance of this discharge in relation to other loads entering the river during the same time period.

To make load estimations, flow estimates were made using the four different techniques described in the hydrology section. The estimated yield from the four methods is summarized in Table 8. This projected flow is considered to have a time of discharge similar to that given for the average value in Table 7.

In order to make constituent load projections, water quality concentrations for monitored streams are assumed to be the median values given in Table 9. For those drainage basins where no water quality data are available, estimates of concentrations were made using water quality data from adjacent basins with similar characteristics. In most cases, the basins without data were the smaller, low-elevation watershed and represent only about 15 percent of the total drainage area.

The reader is cautioned that the estimation technique used here is only a first approximation. It should not be viewed a scientific calculation. Using average annual flow and median values of concentration does not allow an accurate estimate of temporal variation of mass loading. The technique was used to make these estimates because the data base was insufficient to make a more detailed temporal calculation. The estimation conducted here should only be looked upon to give the relative magnitude of the mass loading.

Loading of constituents is calculated using:

FOR SELENIUM

$$\text{Discharge (AF)} \bullet \frac{1\ \text{Liter}}{0.81 \times 10^{-6}\text{AF}} \bullet \text{Selenium } (\mu g/L) \bullet \frac{1\ g}{10^{6}\ \mu g} \bullet \frac{Kg}{1{,}000\ g} \bullet \frac{2.2\ \text{lbs}}{Kg}$$

$$[\text{Discharge (AF)}] \bullet [\text{Selenium } (\mu g/L)] \bullet [0.002716] = \text{lbs Se}$$

FOR MOLYBDENUM

$$\text{Discharge (AF)} \bullet \frac{1\ \text{Liter}}{0.81 \times 10^{-6}\text{AF}} \bullet \text{Molybdenum } (\mu g/L) \bullet \frac{1\ g}{10^{6}\ \mu g} \bullet \frac{Kg}{1{,}000\ g} \bullet \frac{2.2\ \text{lbs}}{Kg}$$

$$[\text{Discharge (AF)}] \bullet [\text{Molybdenum } (\mu g/L)] \bullet [0.002716] = \text{lbs Mo}$$

FOR BORON

$$\text{Discharge (AF)} \bullet \frac{1\ \text{Liter}}{0.81 \times 10^{-6}\text{AF}} \bullet \text{Boron } (mg/L) \bullet \frac{1\ g}{10^{3}\ mg} \bullet \frac{Kg}{1{,}000\ g} \bullet \frac{2.2\ \text{lbs}}{Kg}$$

$$[\text{Discharge (AF)}] \bullet \text{Boron } (mg/L)] \bullet [2.716] = \text{lbs Boron}$$

FOR SALT

$$\text{Discharge (AF)} \bullet \frac{1\ \text{Liter}}{0.81 \times 10^{-6}\text{AF}} \bullet \text{Salt } (\mu mhos/cm) \bullet 0.64 \frac{mg/L}{\mu mhos/cm} \bullet \frac{1\ g}{10^{3}\ mg} \bullet \frac{Kg}{1{,}000\ g} \bullet \frac{2.2\ \text{lbs}}{Kg}$$

$$[\text{Discharge (AF)}] \bullet [\text{Salt } (\mu mhos/cm)] \bullet [0.64] \bullet [2.716] = \text{lbs salt}$$

Using the discharge given in Table 8 and the median concentrations in Table 9 or from an estimate, the loads for the four discharge methods were calculated. Results are presented for selenium (Table 10), molybdenum (Table 11), boron (Table 12) and salt (Table 13) for each of the methods described earlier for runoff estimation.

Results from the load estimations using median concentrations shows that selenium could vary from 260 to 600 lbs per year depending upon the method used to estimate discharge volume. With Method IV, the discharge from the 6 measured watersheds accounts for 2/3 of the total flow and 45 percent of the estimated selenium load. The remaining 55 percent of the load comes from the mid- to smaller-sized watersheds which would only reach the San Joaquin River during extended, intense winter storm periods. The remainder of the time, this flow is likely to percolate into the ground water in the alluvial fan area of the valley floor. This may account for some of the areas of groundwater that show elevated concentrations of selenium (Lowry, 1988).

The discharge of selenium is assumed to follow the trend shown in Table 7 where almost 75 percent of the discharge occurs in the period January to end March. This is in contrast to the relatively uniform discharge of selenium from the subsurface drainage systems in the Panoche Fan area (Table 14). Figure 3 shows the percentage of annual load that discharges from the subsurface tile drainage systems as compared to the estimate for the streams draining the eastern slope of the Diablo Range. The analysis here shows the majority of the load discharged by the streams occurs during a period of time when maximum flow is occurring in the San Joaquin River thus substantial dilution flows may be available.

There results of the estimation shows the selenium load from the natural streams draining the eastern slope of the Diablo Range to be relatively insignificant when compared to the total load entering the river. The estimated load of selenium originating from the streams is only 3-6 percent of the load discharged by the subsurface tile drainage systems depending upon the method used to estimate the stream discharge flow (Table 14). The actual percentage may be even lower since the four methods used to estimate flow assume that all flow reaches the San Joaquin River which in practice is not the case; therefore, the actual load may be less. Even when the maximum concentration measured in the streams is used in place of the median value in the calculation procedure, the percentage still remains low in comparison to the load discharged by the subsurface tile drainage systems.

The estimated annual load of molybdenum is also very low and ranges from 300 to 500 lbs annually depending upon the method used to estimate flow. The actual load of molybdenum originating from these streams may be less important as the median concentrations in these streams in most instances was less than the median concentrations being found in the San Joaquin River (Westcot et el., 1989).

The estimation technique used here shows a major loading to the San Joaquin River is likely to occur from the boron concentrations that discharge from the streams draining the eastern slope of the Diablo Range (Table 12). The western portion of the San Joaquin River Basin has long been known as an area of elevated boron concentrations. Estimates of boron loads discharged range from 400,000 to 800,000 lbs depending upon the method used to estimate flow from the streams. There are no comparison values available for loads from the subsurface tile drainage systems, but it is likely that the streams discharge a significant load of boron, however, as seen with the selenium discharges over 75 percent of this load may come in the period January thru end-March. This is a period of maximum dilution; therefore, the load is not likely to seriously impact river boron concentrations. Boron loads discharged outside this time period (April-December) have a lower chance of reaching the San Joaquin River and are only likely to impact local ground water.

The estimated annual average load of salt (Table 13) being discharged is large; however, like boron, it comes in a period of maximum dilution flow in the San Joaquin River. It is not likely that the average annual salt discharges will result in an aggravation of the salinity problems in the San Joaquin River that occur in the irrigation season. The average annual salt load varied from 180×10^6 to 320×10^6 lbs depending upon the method used to estimate the average annual flow from the creeks (Table 13).

Figure 3. Distribution of Selenium Load Throughout the Year for Subsurface Drains in the Panoche Fan as Compared to Streams Draining the Eastern Slope of the Diablo Range (Data for Streams Based on Flow Taken from Table 7; Data for Subsurface Drains Taken From SWRCB, 1987)

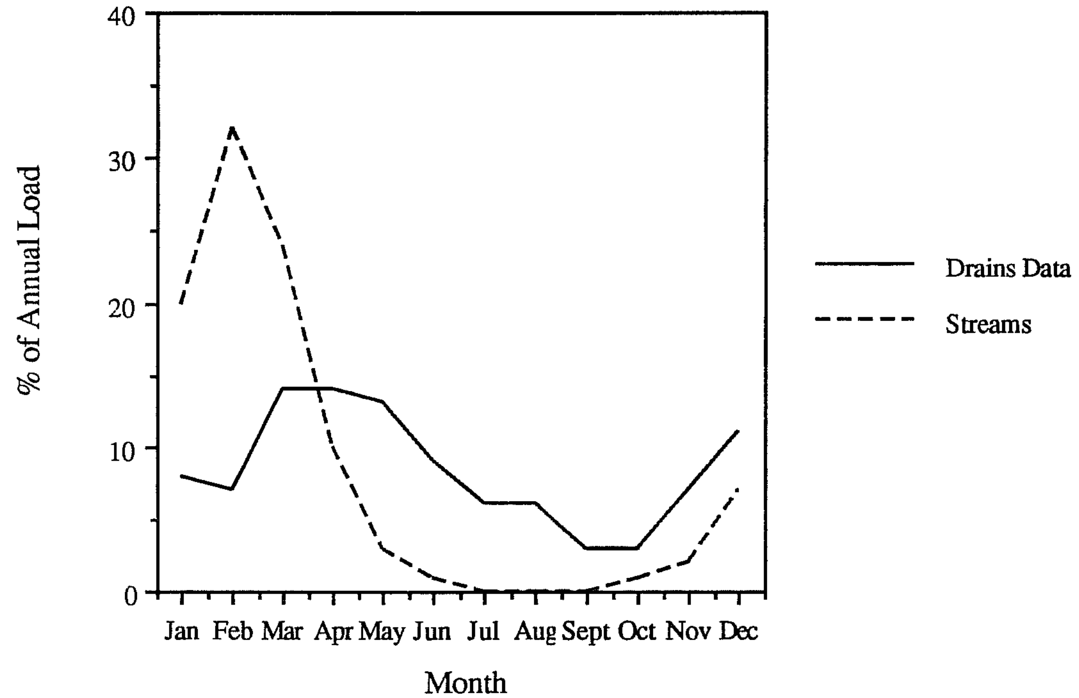

Table 10 - Estimated Selenium Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	SELENIUM LOAD (lbs)			
		Method I	Method II	Method III	Method IV
NORTHERN STREAM GROUP					
1	Sand Creek	22.3	16.6	12.4	4.5
2	Deer Creek	8.7	6.2	4.5	1.7
3	Briones Creek	15.5	13.4	11.7	3.1
4	Marsh Creek	21.8	21.8	21.8	21.8
5	Kellogg Creek	16.8	16.8	16.8	16.8
6	Unknown	13.4	8.3	5.2	2.7
7	Brushy Creek	37.7	24.7	16.2	7.5
8	Bethany Creek	33.3	20.6	12.8	6.7
9	Mountain House Crk	55.6	31.2	17.7	11.1
10	Patterson Run Creek	46.4	23.4	11.9	9.3
MIDDLE STREAM GROUP					
11	Corral Hollow Creek	14.5	12.2	9.7	8.7
12	Deep Gulch Creek	5.3	3.1	1.7	1.1
13	Lone Tree Creek	8.6	6.8	5.2	4.3
14	Hospital Creek	8.1	6.9	5.6	4.0
15	Arkansas-Martin Crk	13.3	8.2	4.8	2.7
16	Ingram Creek	19.5	14.0	9.6	9.8
17	Mile 33 Creek	1.8	1.2	0.8	0.4
18	Kern Creek	8.8	6.1	4.0	1.8
19	Del Puerto Creek	8.8	8.6	8.6	8.6
20	Black Gulch Creek	13.4	9.0	5.9	2.7

Table 10 - (Continued) Estimated Selenium Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	SELENIUM LOAD (lbs)			
		Method I	Method II	Method III	Method IV
21	Unknown	4.1	2.8	1.9	0.8
22	Salado Creek	22.2	17.5	13.1	11.1
23	Little Salado Creek	10.1	7.8	5.7	2.0
24	Crow Creek	50.6	40.0	30.3	25.3
25	Unknown	7.1	4.1	2.3	1.4
26	Orestimba Creek	33.5	33.5	33.5	33.5
27	Bennett Valley Crk	10.7	7.3	4.8	2.1
28	Garzas Creek	6.4	6.1	5.5	5.1
29	Mustang Creek	0.9	0.6	0.4	0.2
30	Quinto Creek	3.5	3.0	2.4	1.8
31	Romero Creek	2.7	2.2	1.8	1.3
SOUTHERN STREAM GROUP					
32	Los Banos Creek	16.5	16.5	16.5	16.5
33	Salt Creek	2.6	3.9	2.2	0.5
34	Ortigalita Creek	20.6	13.0	9.1	8.3
35	Unknown	1.6	1.5	0.8	0.3
36	Laguna Seca Creek	0.9	0.9	0.5	0.2
37	Wildcat Canyon Crk	3.9	3.7	2.0	0.8
38	Little Panoche Crk	3.3	2.1	1.4	1.3
39	Moreno Gulch Creek	8.6	8.3	4.5	1.7
40	Panoche-Silver Crk	20.2	20.2	20.2	20.2
	TOTAL	**603.4**	**454.1**	**345.8**	**263.7**

Table 11 - Estimated Molybdenum Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	MOLYBDENUM LOAD (lbs)			
		Method I	Method II	Method III	Method IV
NORTHERN STREAM GROUP					
1	Sand Creek	51.5	38.2	28.6	10.3
2	Deer Creek	7.9	5.7	4.1	1.6
3	Briones Creek	5.8	5.0	4.4	1.1
4	Marsh Creek	32.7	32.7	32.7	32.7
5	Kellogg Creek	7.6	7.6	7.6	7.6
6	Unknown	4.0	2.5	1.5	0.8
7	Brushy Creek	11.3	7.4	4.9	2.3
8	Bethany Creek	10.0	6.2	3.8	2.0
9	Mountain House Crk	9.0	5.0	2.9	1.8
10	Patterson Run Creek	14.0	7.0	3.6	2.8
MIDDLE STREAM GROUP					
11	Corral Hollow Creek	21.8	18.3	14.6	13.1
12	Deep Gulch Creek	5.3	3.1	1.7	1.1
13	Lone Tree Creek	7.5	6.0	4.6	3.8
14	Hospital Creek	12.1	10.3	8.4	6.0
15	Arkansas-Martin Crk	4.0	2.4	1.4	0.8
16	Ingram Creek	6.8	4.9	3.3	3.4
17	Mile 33 Creek	0.5	0.4	0.2	0.1
18	Kern Creek	2.0	1.4	0.9	0.4
19	Del Puerto Creek	21.5	21.5	21.5	21.5
20	Black Gulch Creek	7.3	5.0	3.2	1.5

Table 11 - (Continued) Estimated Molybdenum Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	MOLYBDENUM LOAD (lbs)			
		Method I	Method II	Method III	Method IV
21	Unknown	1.2	0.9	0.6	0.2
22	Salado Creek	8.6	6.7	5.1	4.3
23	Little Salado Creek	3.0	2.3	1.7	0.6
24	Crow Creek	9.5	7.5	5.7	4.7
25	Unknown	1.3	0.8	0.4	0.3
26	Orestimba Creek	50.2	50.2	50.2	50.2
27	Bennett Valley Crk	2.0	1.4	0.9	0.4
28	Garzas Creek	19.1	18.3	16.6	15.3
29	Mustang Creek	2.7	1.8	1.2	0.5
30	Quinto Creek	10.6	8.9	7.2	5.3
31	Romero Creek	8.1	6.7	5.3	4.0
SOUTHERN STREAM GROUP					
32	Los Banos Creek	49.7	49.7	49.7	49.7
33	Salt Creek	0.8	1.2	0.7	0.2
34	Ortigalita Creek	6.2	3.4	2.7	2.5
35	Unknown	0.5	0.5	0.2	0.1
36	Laguna Seca Creek	0.3	0.3	0.1	0.1
37	Wildcat Canyon Crk	1.2	1.1	0.6	0.2
38	Little Panoche Crk	9.9	6.2	4.3	4.0
39	Moreno Gulch Creek	2.6	2.5	1.3	0.5
40	Panoche-Silver Crk	53.8	53.8	53.8	53.8
	TOTAL	**478.6**	**414.8**	**362.2**	**311.6**

Table 12 - Estimated Boron Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	BORON LOAD (lbs)			
		Method I	Method II	Method III	Method IV
	NORTHERN STREAM GROUP				
1	Sand Creek	23,500	17,400	13,000	4,700
2	Deer Creek	2,900	2,100	1,500	600
3	Briones Creek	7,700	6,700	5,900	1,600
4	Marsh Creek	65,500	65,500	65,500	65,500
5	Kellogg Creek	32,600	32,600	32,600	32,600
6	Unknown	13,400	8,300	5,200	2,700
7	Brushy Creek	19,600	12,800	8,400	3,900
8	Bethany Creek	46,600	28,800	17,900	9,300
9	Mountain House Crk	48,500	27,200	15,400	9,700
10	Patterson Run Creek	65,000	32,800	16,700	13,000
	MIDDLE STREAM GROUP				
11	Corral Hollow Creek	68,200	57,800	45,800	41,000
12	Deep Gulch Creek	14,100	8,200	4,600	2,800
13	Lone Tree Creek	14,600	11,700	8,900	7,300
14	Hospital Creek	7,600	6,500	5,200	3,800
15	Arkansas-Martin Crk	10,700	6,500	3,800	2,100
16	Ingram Creek	27,300	19,600	13,400	13,600
17	Mile 33 Creek	3,600	2,400	1,600	700
18	Kern Creek	13,600	9,300	6,100	2,700
19	Del Puerto Creek	22,900	22,900	22,900	22,900
20	Black Gulch Creek	3,000	2,000	1,300	600

Table 12 - (Continued) Estimated Boron Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	BORON LOAD (lbs)			
		Method I	Method II	Method III	Method IV
21	Unknown	3,300	2,300	1,500	700
22	Salado Creek	9,100	7,200	5,400	4,600
23	Little Salado Creek	4,100	3,100	2,300	800
24	Crow Creek	13,900	11,000	8,300	7,000
25	Unknown	1,800	1,000	600	400
26	Orestimba Creek	10,700	10,700	10,700	10,700
27	Bennett Valley Crk	13,400	9,100	6,000	2,700
28	Garzas Creek	5,100	4,900	4,400	4,100
29	Mustang Creek	3,600	2,400	1,600	700
30	Quinto Creek	7,700	6,500	5,300	3,900
31	Romero Creek	9,100	7,600	6,000	4,600
SOUTHERN STREAM GROUP					
32	Los Banos Creek	9,300	9,300	9,300	9,300
33	Salt Creek	13,000	19,600	11,000	2,600
34	Ortigalita Creek	23,500	14,800	10,300	9,400
35	Unknown	3,200	3,000	1,600	600
36	Laguna Seca Creek	1,700	1,700	1,000	400
37	Wildcat Canyon Crk	7,800	7,400	3,900	1,600
38	Little Panoche Crk	42,200	26,500	18,500	16,900
39	Moreno Gulch Creek	17,100	16,600	8,900	3,400
40	Panoche-Silver Crk	80,700	80,700	80,700	80,700
	TOTAL	**791,200**	**626,000**	**493,000**	**406,200**

Table 13 - Estimated Salt Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	SALT LOAD (lbs x 10^6)			
		Method I	Method II	Method III	Method IV
NORTHERN STREAM GROUP					
1	Sand Creek	11.0	8.2	6.1	2.2
2	Deer Creek	8.3	6.0	4.3	1.7
3	Briones Creek	7.4	6.5	5.6	1.5
4	Marsh Creek	16.8	16.8	16.8	16.8
5	Kellogg Creek	5.9	5.9	5.9	5.9
6	Unknown	2.6	1.6	1.0	0.5
7	Brushy Creek	5.3	3.5	2.3	1.1
8	Bethany Creek	8.5	5.3	3.3	1.7
9	Mountain House Crk	14.5	8.1	4.6	2.9
10	Patterson Run Creek	11.9	6.0	3.1	2.4
MIDDLE STREAM GROUP					
11	Corral Hollow Creek	18.6	15.6	12.5	11.1
12	Deep Gulch Creek	4.5	2.6	1.5	0.9
13	Lone Tree Creek	4.8	3.8	2.9	2.4
14	Hospital Creek	4.4	3.8	3.1	2.2
15	Arkansas-Martin Crk	3.4	2.1	1.2	0.7
16	Ingram Creek	5.8	4.2	2.9	2.9
17	Mile 33 Creek	0.5	0.3	0.2	0.1
18	Kern Creek	5.0	3.4	2.2	1.0
19	Del Puerto Creek	12.4	12.4	12.4	12.4
20	Black Gulch Creek	3.6	2.5	1.6	0.7

Table 13 - (Continued) Estimated Salt Loads from Watersheds Draining the Eastern Slope of the Diablo Range Based on Four Methods of Calculating Average Streamflow and Utilizing Median Concentrations from Available Water Quality Data

Watershed Number	CREEK NAME	SALT LOAD (lbs X 10^6) Method I	Method II	Method III	Method IV
21	Unknown	2.1	1.5	1.0	0.4
22	Salado Creek	9.5	7.5	5.6	4.7
23	Little Salado Creek	5.2	4.0	2.9	1.0
24	Crow Creek	19.4	15.4	11.6	9.7
25	Unknown	2.9	1.7	0.9	0.6
26	Orestimba Creek	16.1	16.1	16.1	16.1
27	Bennett Valley Crk	6.8	4.7	3.0	1.4
28	Garzas Creek	6.0	5.8	5.2	4.8
29	Mustang Creek	2.3	1.6	1.0	0.5
30	Quinto Creek	4.2	3.6	2.9	2.1
31	Romero Creek	3.4	2.9	2.3	1.7
SOUTHERN STREAM GROUP					
32	Los Banos Creek	11.7	11.7	11.7	11.7
33	Salt Creek	2.9	4.4	2.5	0.6
34	Ortigalita Creek	15.1	9.5	6.6	6.0
35	Unknown	1.2	1.1	0.6	0.2
36	Laguna Seca Creek	0.6	0.6	0.4	0.1
37	Wildcat Canyon Crk	2.9	2.7	1.4	0.6
38	Little Panoche Crk	7.2	4.5	3.1	2.9
39	Moreno Gulch Creek	6.2	6.0	3.2	1.2
40	Panoche-Silver Crk	39.8	39.8	39.8	39.8
	TOTAL	**320.7**	**263.7**	**215.3**	**177.2**

Table 14 - Estimated Monthly Distribution of Selenium Load Throughout the Year for Subsurface Drains in the Panoche Fan as Compared to Streams Draining the Eastern Slope of the Diablo Range

Month	SELENIUM LOAD (lbs)				
	Method I	Method II	Method III	Method IV	Subsurface Drains
January	120	91	69	53	694
February	193	145	111	86	619
March	145	110	83	64	1,330
April	60	45	35	26	1,268
May	18	12	9	5	1,191
June	6	5	4	3	840
July	0	0	0	0	540
August	0	0	0	0	518
September	0	0	0	0	268
October	6	5	4	3	318
November	12	9	7	5	660
December	43	32	24	19	976
TOTAL	**603**	**454**	**346**	**264**	**9,222**

Data Sources: Stream Loads Taken from Table 7 and Table 10
Subsurface Drain Loads Taken from SWRCB, 1987

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APPENDIX A

WATERSHED DESCRIPTIONS AND WATER QUALITY DATA

Note: Throughout Appendix A, Elevation Above Mean Sea Level is designated as MSL

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1. SAND CREEK (Contra Costa County)

Sand Creek is a small, low-elevation watershed covering approximately 11 square miles (Figure A-1). Sand Creek has one major tributary from Oil Canyon. Elevation ranges from a maximum of 1,500 feet above sea level in the extreme western edge of the watershed to approximately 200 feet as the creek flows through Lone Tree Valley near the water quality sampling point at Deer Valley Road.

The topography in the watershed varies with slopes dropping steeply to the valley floor. The valley floor of Sand Creek slopes eastward from elevation 700 feet to 200 feet above sea level in a distance of approximately 5 miles. The steep sloping areas make up only a small portion of the watershed with the wide, flat, stream valley floor making up the greatest portion.

Rainfall in the watershed varies from 20 inches in the higher elevations to the west but drops to 13 inches or less in the eastern portion of the watershed. Vegetation closely follows the rainfall patterns. Scattered hardwood forests are located on the areas above 1000 feet in elevation while grasses and forbes predominate on the greatest portion of the watershed or areas below 1000 feet. Cattle grazing is seen extensively throughout the watershed.

The northwest portion of the watershed and the Empire Mine area (near the old town of West Hartley) contain abandoned lignite mines. Much of this area is now within the Black Diamond Mines Regional Park. The Old Empire Mine is the largest mine in the watershed. This mine was inspected by Sterling Davis of the Regional Board staff in the winter of 1986-87. Flow out of the plugged mine shaft was 15 gpm (0.03 cfs) with a pH of 2.6 and an EC of 4,400 μmhos/cm. Discharge from the mine does not flow into Sand Creek under normal conditions but may during or immediately after a heavy rainfall period. Other than this potential discharge, all flow in the creek is natural runoff or seepage.

Water quality sampling was conducted on Sand Creek at the point where the creek passes under Deer Valley Road. The creek contained high salt and boron including during periods of higher flow. The median salinity and boron were 3,000 μmhos/cm and 4.1 mg/L, respectively (Table A-1). The limited trace element sampling showed a median selenium and molybdenum concentration of 3.9 and 9 μg/L, respectively (Table A-2).

2. DEER VALLEY CREEK (Contra Costa County)

Deer Valley Creek is a very small, low-elevation watershed covering approximately 5 square miles (Figure A-1). Deer Creek has no tributaries and drains only the watershed in Deer Valley. Elevation ranges from 1,000 feet above sea level along the ridge lines to approximately 250 feet as the creek flows near the water quality sampling point at Deer Valley Road.

The topography in the watershed has steep slopes near the ridge lines, but breaks off quickly to a wide flat valley floor. The valley floor slopes gently in a southeast direction with elevations ranging from 500 to 250 feet above sea level in a distance of approximately 3 miles. The wide flat valley makes up greater than 75 percent of the total watershed area.

Rainfall in the watershed varies from 18 inches in the highest elevations in the northwest but drops to 13 inches or less in the eastern portion of the watershed. Because of the limited elevation change in the watershed, elevation is unlikely to be a major influence on rainfall amounts. Vegetation in the watershed is limited by elevation and rainfall. Scattered hardwood trees exist in areas above 1000 feet in elevation, but the majority of the watershed is grasses and forbes. Cattle grazing is seen extensively throughout the watershed.

There are no known discharges that would affect water quality. There are several small cattle-watering ponds along the creek that store small amounts of water (<50 acre-feet each).

Water quality sampling was conducted on Deer Creek at the point where the creek passes under Deer Valley Road. During the limited sampling period, the creek contained high salt; however, the boron concentrations were significantly less than those found in Sand Creek, the watershed immediately to the north. Median salinity and boron were 4,950 μmhos/cm and 1.1 mg/L respectively (Table A-3). Limited trace element analysis showed a median selenium and molybdenum concentration similar to those found in Sand Creek to the north. Median concentrations of selenium and molybdenum were 3.3 and 3 μg/L, respectively (Table A-4).

3. BRIONES VALLEY CREEK (Contra Costa County)

Briones Valley Creek is a small, low-elevation watershed covering approximately 7.5 square miles (Figure A-1). Several small tributaries join the creek in the higher elevation area. Elevation ranges from a maximum of 1,600 feet above sea in the western portion of the watershed to approximately 250 feet as the creek flows under Deer Valley Road. Briones Valley Creek continues to Marsh Creek Reservoir (Elev. 175 feet).

The topography in the watershed varies with a cluster of high elevation hills in the western portion of the watershed. The higher elevation area is commonly over 1000 feet above sea level and covers of approximately one square mile. This area slopes steeply to the valley floor with the Briones Valley sloping eastward from 700 to less than 200 feet above sea level in a distance of 7 miles. Areas with an elevation of less than 800 feet above sea level make up the greatest portion of the watershed.

Rainfall in the watershed varies from near 20 inches in the higher elevations to 13 inches or less in the eastern portion of the watershed. Elevation change in the watershed is unlikely to be a major influence on rainfall amounts or distribution. Vegetation in the watershed is limited by elevation and rainfall. Scattered hardwood tree areas exist in the areas above 1000 feet in elevation, but the majority of the watershed is composed of grasses and forbes. Cattle grazing is seen extensively throughout the watershed.

Figure A-1. Location of Sand Creek, Deer Valley Creek and Briones Valley Creek Watersheds in Contra Costa County.

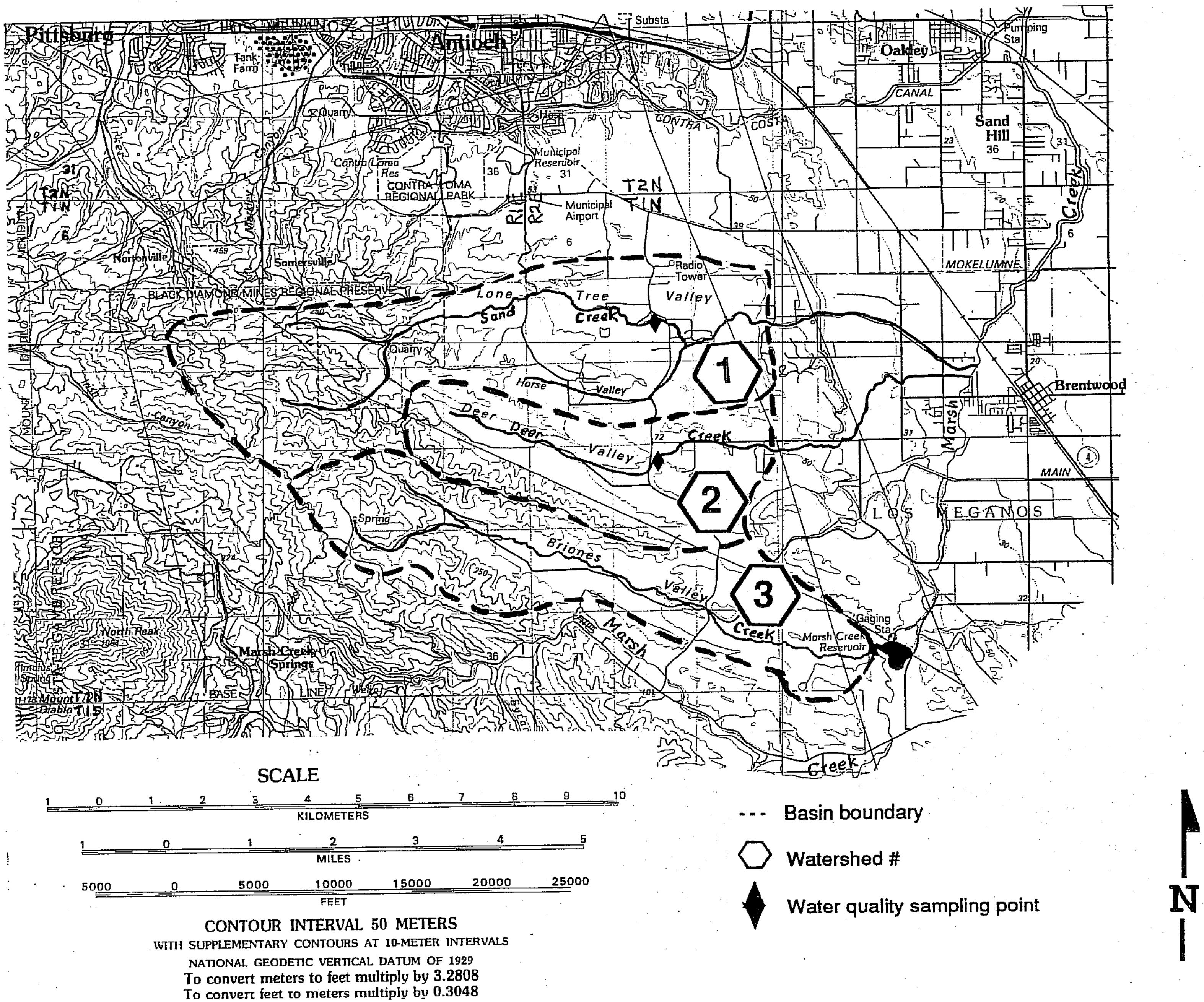
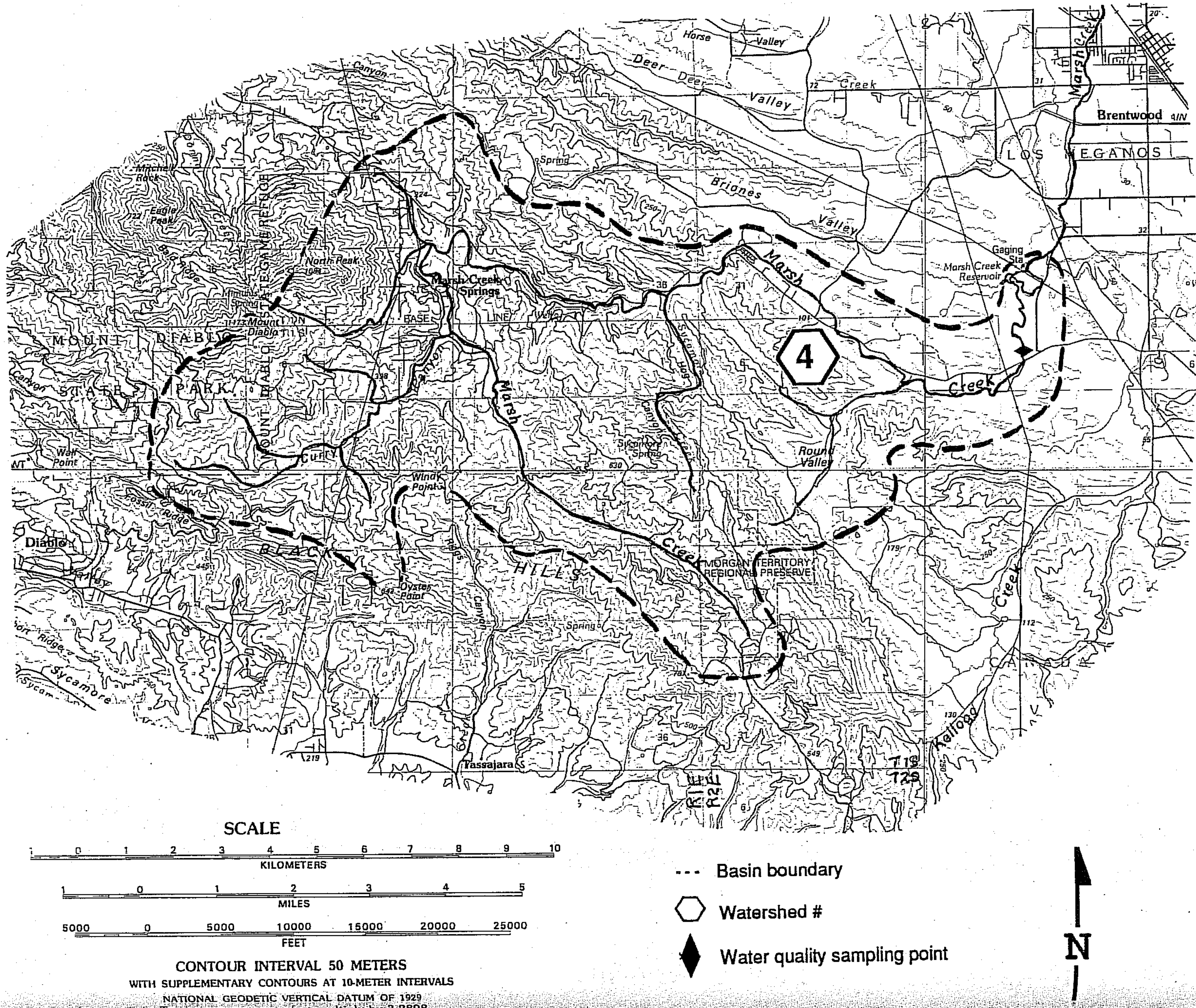


Figure A-2. Location of the Marsh Creek Watershed in Contra Costa County.



There are no known discharges that would affect water quality. There are several small cattle-watering ponds along the creek that store small amounts of water (<50 acre feet each). No water quality sampling has been conducted on Briones Valley Creek.

4. MARSH CREEK (Contra Costa County)

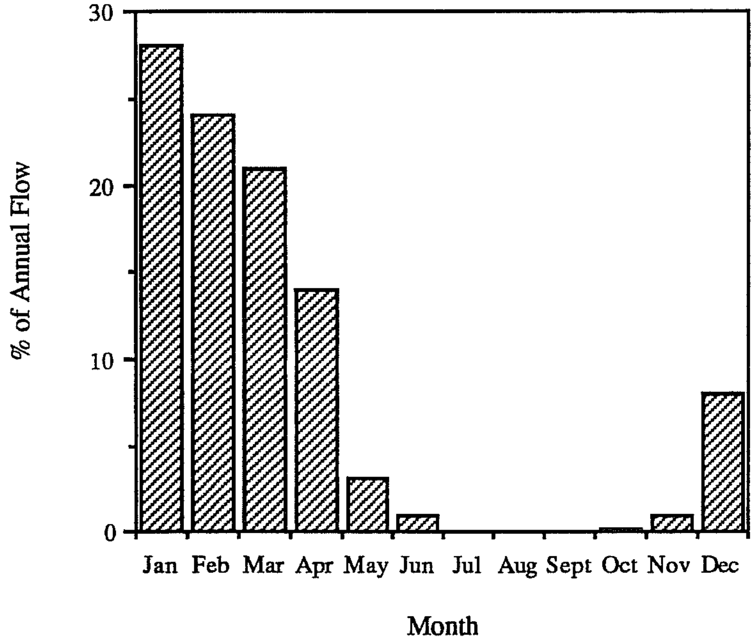
Marsh Creek watershed is the largest in the northern study zone. The watershed covers 42.6 square miles (Figure A-2) above the water quality sampling point at Marsh Creek Road. Marsh Creek flows north beyond this point in a man-made channel and exits into the Delta outflow near the town of Oakley. Marsh Creek has two main tributaries, one from Curry Canyon and the other from Hog Canyon (Sycamore Creek).

Marsh Creek is strongly influenced by the topography in the watershed. Elevation ranges from a maximum of 3,850 feet above sea level in the western portion of the watershed to approximately 175 feet at the water quality sampling point at Marsh Creek Road, 5 miles west of Byron, California. The western portion of the watershed is dominated by Mt. Diablo, which is the highest peak in the immediate area, and rises to 3,850 feet and North Peak, which rises to 3,435 feet above sea level. These high-elevation areas cover 40-50 percent of the watershed. The watershed then quickly becomes a long narrow flood plain valley surrounded by low elevation (<1,000 feet MSL) rolling hills.

Rainfall in the watershed is strongly influenced by the topography. Rainfall exceeds 25-30 inches in the vicinity of Mt. Diablo and North Peak in the west but drops to 13 inches or less in the eastern portion of the watershed. The majority of the Marsh Creek streamflow originates in the higher elevation areas and is strongly influenced by winter rainfall periods. USGS (1985) records indicate that the maximum flow rates at the Marsh Creek Road sampling site have approached 6,000 cfs, but there are many days, especially in late summer, when there is no flow being recorded. The average annual discharge for a 30-year period of record (1953-1983) is 8,040 acre-feet per year. During this period, the annual discharge varied from 39,940 to zero depending upon the rainfall year. The average yield is approximately 190 acre-feet per square mile (Table 6). The runoff is not uniform throughout the year. Heavy flows occur in the winter rainfall periods with flows decreasing through spring and summer months with some months showing no flow. Figure A-3 shows the average percentage of flow for each month for the 30-year period of record.

Vegetation in the watershed closely follows the rainfall patterns. Hardwood forests are extensive in areas above 1,200 feet MSL, an area that covers about one-half of the watershed. The remaining area is covered by grass and forbes including large patches interspersed in the hardwood forest. Small areas of chaparral and mountain brush exist at the higher elevations on Mt. Diablo, but the total area represents only a few percent of the total watershed area. Cattle grazing is seen extensively throughout the area.

Figure A-3 Distribution of Streamflow Throughout the Year for Marsh Creek Based Upon a 30-Year Period of Record (1953-1983).



Water quality in Marsh Creek is influenced by two non-point sources, mining and suburban farming. The Mount Diablo Mine is an abandoned mercury mine, which discharges very acidic, saline water. A surface impoundment at the base of the mine tailings has prevented most of the discharge from flowing into any surface drainage. During periods of heavy rainfall, however, water from the mine tailings flows into Dunn and Horse Creeks, two ephemeral creeks which flow into Marsh Creek. Fishing is prohibited in Marsh Creek Reservoir, one mile downstream of the water quality sampling station at Marsh Creek Road, because of high levels of mercury in the reservoir. These high levels are from previous mine discharges. In addition to the mine discharge, the entire flood plain area of Marsh Creek is residential and small farming operations that either pump ground water or divert directly from Marsh Creek. Their exact impact on stream hydrology and quality is unknown.

Water quality sampling was conducted on Marsh Creek at the point where the creek passes under Marsh Creek Road (at the former USGS gaging station). During the limited sampling period, median salinity and boron concentrations were 1,200 μmhos/cm and 3.0 mg/L, respectively (Table A-5). Although the boron concentrations are elevated in this stream, the limited trace element data base showed low selenium and molybdenum concentrations. Median selenium and molybdenum concentrations were 1.0 and <5 μg/L, respectively (Table A-6).

5. KELLOGG CREEK (Contra Costa and Alameda Counties)

Kellogg Creek is a low-elevation watershed covering approximately 20 square miles (Figure A-4). Kellogg Creek flows from the southwest to the northeast and has several small tributaries that join the creek in the higher elevation areas. Elevation ranges from a maximum of 2,250 feet above sea level along the southwestern ridges to approximately 180 feet as the creek flows near the water quality sampling point on Vasco Road.

The topography in the watershed varies with a high ridge line on the western and southern boundaries of the watershed giving way to low-elevation rolling hills. Although a few of the highest points along the ridge line exceed 2,000 feet above sea level, the general elevation is more commonly 1,000 to 1,200 feet. These 1,000- to 1,200-foot elevation areas make up a significant portion of the watershed. These areas slope steeply to the Kellogg Creek valley floor. These steeply sloping hills are one of the principal reasons this site is being considered for the Los Vaqueros Off-Stream Storage Reservoir of the State Water Project.

Rainfall in the watershed varies from 16 inches near the highest points to 13 inches or less in the northeast portion of the watershed. Because of the limited elevation change in the watershed, elevation is unlikely to be a major influence in rainfall amounts. Flow in Kellogg Creek is strongly influenced by winter rainfall periods. Only limited flow records are available for Kellogg Creek (1958-1977). Flow patterns for the creek have been simulated for the period 1921 to present as part of the study being conducted for the Los Vaqueros Reservoir Project (CCWD, 1990). This simulation shows the average annual discharge for this 69-year period (1921-1989) to be 1,875 acre-feet per year. The annual discharge varied from 9,570 to 10 depending upon the rainfall year, but the average yield is approximately 95 acre-feet per square mile (Table 6). The runoff is not uniform throughout the year. Heavy flows occur in winter rainfall periods with flows decreasing through spring and summer months with flow essentially zero from June through end-September. Figure A-5 shows the average percentage of flow for each month for the 69-year period.

Vegetation in the watershed closely follows the rainfall patterns. Scattered hardwood tree areas exist above 800 feet along the northern facing slopes of the extreme southwestern ridge line. These hardwood tree areas make up only about 20 percent of the watershed area with the majority of the watershed being in grasses and forbes. Cattle grazing is seen extensively throughout the watershed.

There are no known discharges that would affect water quality. There are several small cattle-watering ponds along the creek that store small amounts of water (<50 acre-feet).

Figure A-4. Location of Kellogg Creek and Brushy Creek Watersheds in Contra Costa and Alameda Counties as Well as an Unnamed Creek Watershed Near Byron Hot Springs in Contra Country.

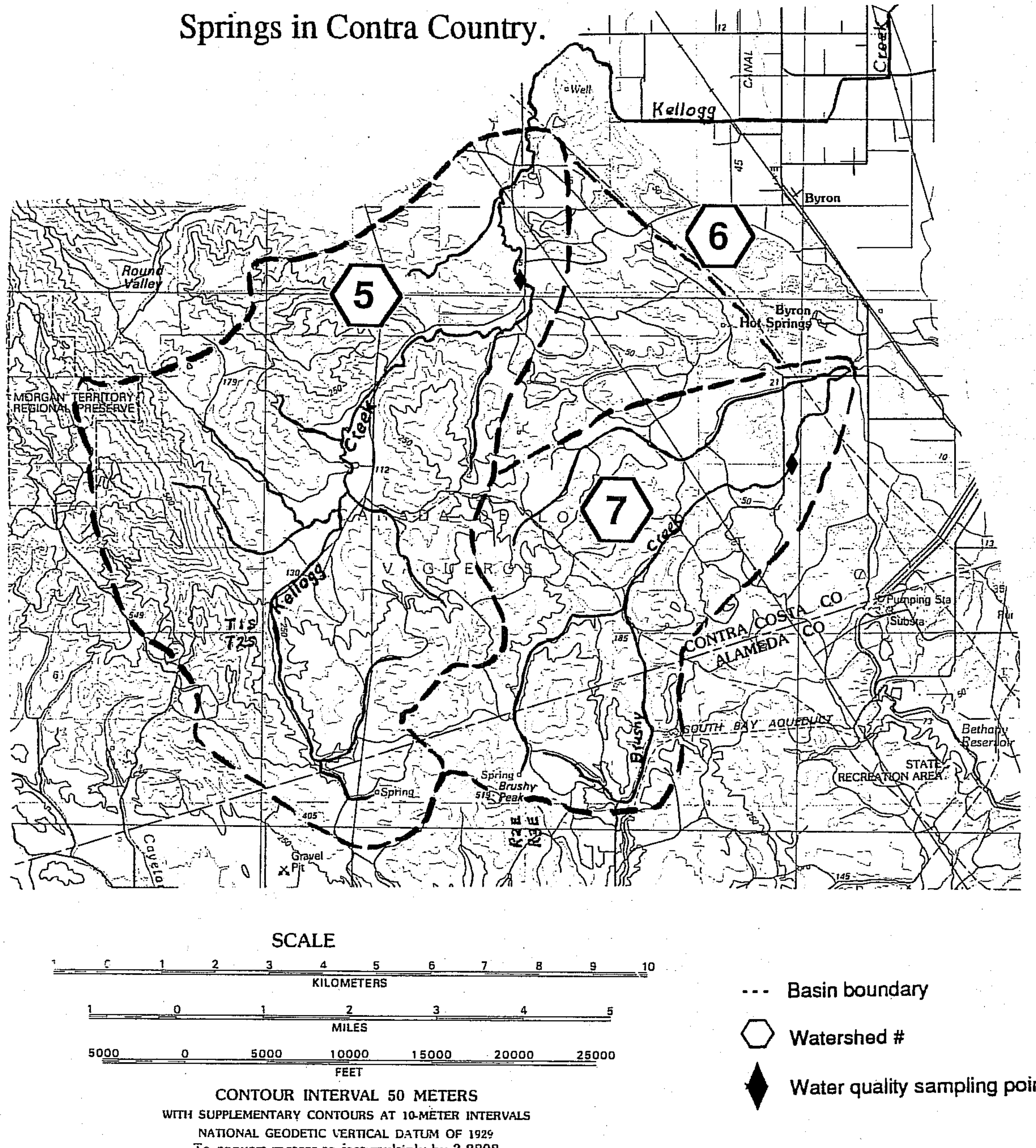
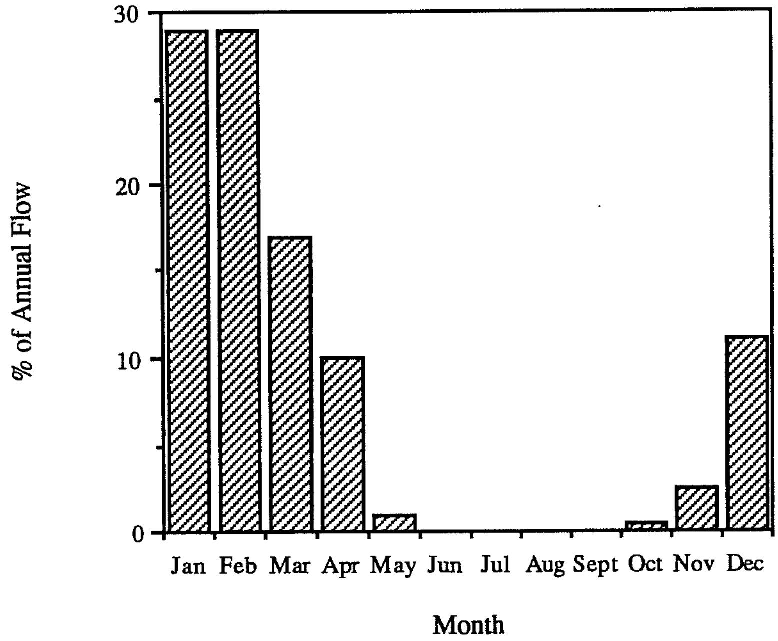


Figure A-5 Distribution of Streamflow Throughout the Year for Kellogg Creek Based Upon a 69- Year Simulated Period of Record (1921-1989).



Water quality sampling was conducted on Kellogg Creek 1.5 miles south of the Vasco Road and Camino Diablo Road intersection. In addition, water quality sampling has been conducted by the California Department of Water Resources and Contra Costa Water District. These three sampling programs show median salinity and boron concentrations of 1,800 µmhos/cm and 6.4 mg/L, respectively (Table A-7). The elevated boron concentrations in this stream are coupled by elevated selenium concentrations. Median selenium and molybdenum concentrations were 3.3 and <5 µg/L, respectively (Table A-8).

6. UNNAMED CREEK NEAR BYRON HOT SPRINGS (Contra Costa County)

This unnamed creek is a small, low-elevation watershed covering approximately 5.2 square miles (Figure A-4). Elevation in the watershed ranges from 1,000 feet above sea level in the west to approximately 100 feet as it flows into the valley floor near Byron Hot Springs.

The topography in the watershed is low hills in the west quickly breaking to gently rolling hills throughout the watershed. The general elevation in the watershed is 200-500 feet above sea level with only isolated areas above and below this range.

Rainfall in the watershed is low and averages about 13-14 inches. Elevation does not influence rainfall patterns in this watershed. The entire watershed is covered with grasses and forbes with almost no trees present. Cattle grazing is seen extensively throughout the area.

There are no known discharges that would affect water quality. The stream is fed by several small ephemeral springs. Because of these springs, one sizeable reservoir has been constructed (50 acres) in one portion of the upper watershed. No water quality sampling has been conducted in the watershed.

7. BRUSHY CREEK (Alameda and Contra Costa Counties)

Brushy Creek watershed is a small, low-elevation watershed covering approximately 14.6 square miles (Figure A-4). Many small tributaries form where springs feed water into Brushy Creek during the wet season. Elevation ranges from 1,700 feet above sea level at Brushy Peak in the extreme western portion of the watershed to approximately 100 feet where Brushy Creek discharges onto the Valley floor area south of Byron Hot Springs.

The topography in the watershed is low hills in the west with elevations between 600-1,200 feet above sea level. They form gently rolling hills as you move east in the watershed. There are only isolated areas in the watershed above the 1,000-foot elevation.

Rainfall in the watershed varies between 12-15 inches. Elevation does not influence rainfall patterns. The entire watershed is covered with grasses and forbes with only one isolated area of trees located near Brushy Peak. Cattle grazing is seen extensively throughout the area.

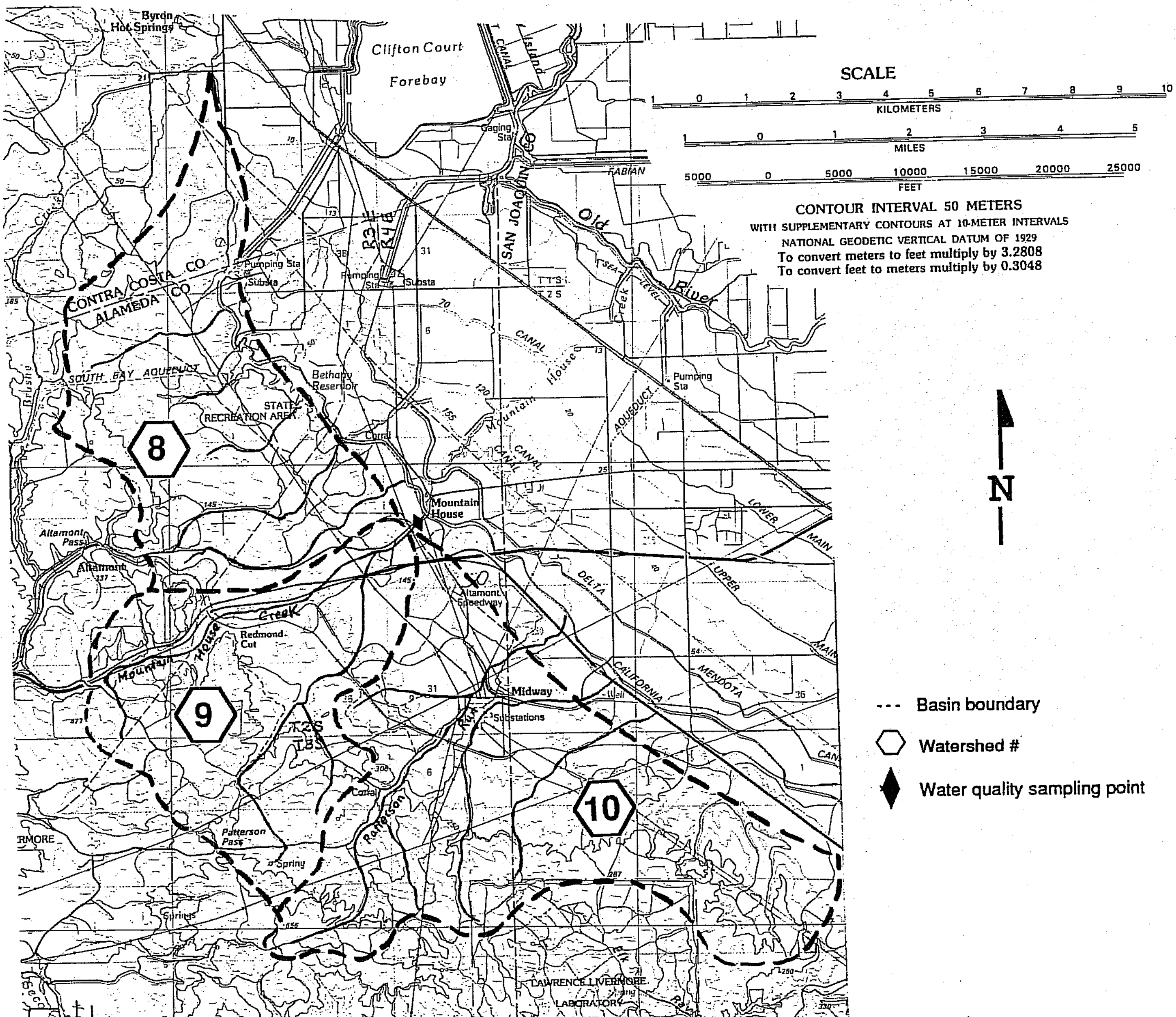
There are no known discharges that would affect water quality. This stream is fed by several small ephemeral springs. These springs provide a good source of cattle-drinking water. Because of these springs, several small reservoirs have been constructed in the higher elevations of this watershed.

No water quality sampling was conducted during this study; however, extensive mineral water quality data has been collected on this creek by the Department of Water Resources as part of their studies for the State Water Project as Brushy Creek discharges into the Delta near the State Project export pumps. The Department's data shows a median salinity and boron concentration of 1,100 μmhos/cm and 2.6 mg/L, respectively (Table A-9).

8. BETHANY RESERVOIR AREA (Alameda and Contra Costa Counties)

Several small unnamed creeks flow into the Bethany Reservoir area. All of these creeks originate in very small, low-elevation watersheds. The 5 to 6 creeks have a watershed that covers 12.9 square miles (Figure A-6). Each watershed is very small and only covers a few square miles. Elevation in these watersheds ranges from 600-800 feet above sea level to approximately 250 feet at Bethany Reservoir.

Figure A-6. Location of Creeks in the Bethany Reservoir Area and Mountain House Creek and Patterson Run Watersheds in Alameda, Contra Costa and San Joaquin Counties.



The topography is low rolling hills and does not play a role in the rainfall distribution. Rainfall averages 13 inches per year. The entire watershed is covered with grasses and forbes. Cattle grazing is extensively practiced throughout the watershed. No water quality sampling has occurred in this area.

9. MOUNTAIN HOUSE CREEK (Alameda County)

Mountain House Creek is one of two watersheds that drain the eastern slope of the Altamont Pass. The watershed is a low-elevation watershed covering approximately 11.6 square miles (Figure A-6). Mountain House Creek is composed of 2 branches, a northern and southern which converge to form the creek prior to entering the San Joaquin Valley floor. Elevation ranges from a maximum of 1,500 feet in the extreme western portion to 200 feet above level where the creek crosses under the California Aqueduct.

The topography in the watershed is low hills in the west giving way to low rolling hills in the remainder of the watershed. Regardless of the extremes of elevation along the western edge of the watershed, the majority of the watershed is made up of rolling hills that range in elevation from 600 to 1,000 feet above sea level.

Although the watershed covers an extensive area, flow in the creek is low as a result of the low rainfall in the area. Rainfall ranges from 11 to 13 inches per year with the higher amount falling in the extreme western portion of the watershed. Vegetation in the watershed is entirely grasses and forbes. No trees exist, even at the higher elevations, due to the low rainfall and the high wind conditions that prevail in the Altamont Pass area. Cattle grazing is practiced extensively throughout the area.

The area is extensively used for wind-power production. There are no known discharges that would affect water quality. Water quality sampling was conducted on Mountain House Creek where the creek passes under Grant Line Road. During the limited sampling period, median salinity and boron concentrations were 3,775 μmhos/cm and 8.1 mg/L, respectively (Table A-10). Coupled with the strongly elevated boron concentrations in this stream, selenium concentrations were also elevated with a median concentration found in this study of 9.3 μg/L (Table A-11).

10. PATTERSON RUN CREEK (Alameda and San Joaquin Counties)

Patterson Run Creek is the largest of several small creeks that drain the southern portion of the Altamont Pass area. Patterson Run Creek originates at elevations that approach 2,000 feet above sea level and makes up over 50 percent of the 18 square miles (Figure A-6) covered by these small creeks. Four or five small creeks make up the remainder of the area, and these creeks originate at points usually less than 1,000 feet in elevation and may only flow distances of 1-3 miles before entering the valley floor where they cross under Interstate Highway 580. Patterson Run Creek crosses under Interstate Highway 580 about 1 1/2 miles south of Interstate Highway 205.

The topography in the watershed is low hills in the west quickly breaking to gently rolling hills in the middle and eastern portion of the watershed. The topography in the smaller creeks is totally low-elevation rolling hills with all the higher-elevation areas in the Patterson Run Creek drainage.

Rainfall in the watershed varies from 9-11 inches. Elevation does not influence rainfall patterns in this watershed; however, the higher rainfall amounts fall in the western portion of the drainage basin due to the west-to-east flow of moisture. The entire watershed is covered with grasses and forbes. No tree areas exist due to the low rainfall and the high wind conditions that prevail in the Altamont Pass area. Cattle grazing is practiced extensively throughout the area.

The area is extensively used for wind-power production. There are no known discharges that would affect water quality. No water quality sampling was conducted in this watershed.

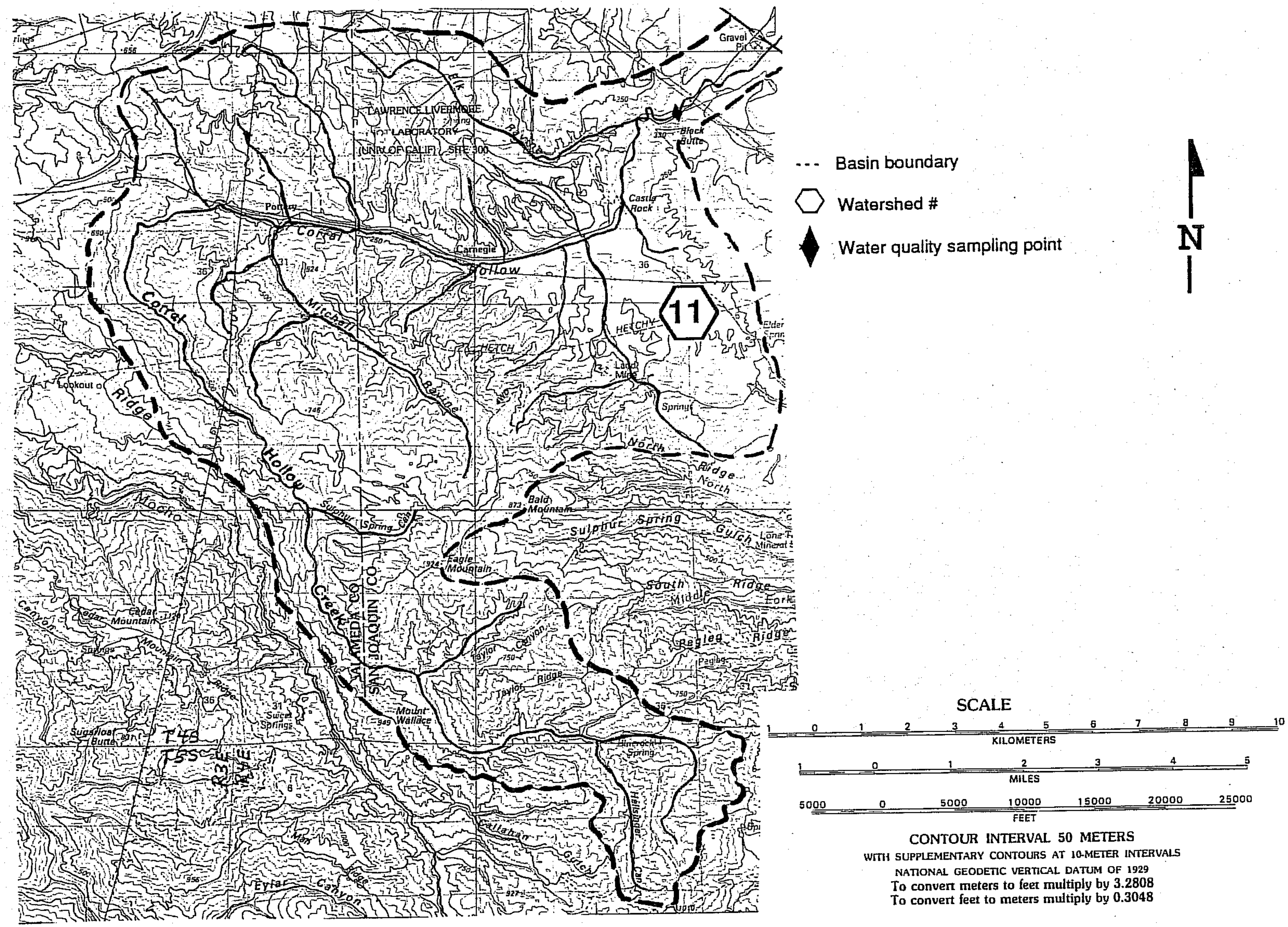
11. CORRAL HOLLOW CREEK (Alameda and San Joaquin Counties)

Corral Hollow Creek is the third largest watershed in the middle study group. The watershed covers 65.2 square miles (Figure A-7) above the point where it flows under Interstate Highway 580. Corral Hollow Creek originates immediately north of Mt. Boardman (3,593 MSL). This area is where the four counties (San Joaquin, Stanislaus, Alameda and Santa Clara) converge. Corral Hollow Creek flows northwest from this point 5-6 miles to the vicinity of Mt. Wallace (3,112 MSL), where it is joined by a major tributary from the Taylor Ridge and Eagle Mountain (3,033 MSL) area, both of which have elevations approaching or exceeding 3,000 feet above sea level. Corral Hollow Creek continues in a northwest direction for 7-8 miles where it makes a turn and begins flowing west to east. The entire length of Corral Hollow Creek, from its origin to where it takes an eastward flowing direction near Tesla is along a steep ridge, which has a southeast to northwest axis. This ridge, which has elevations over 2,000 feet, is less than one-half mile in width.

After the creek begins its eastward flow, it enters a wide flood plain valley characterized by extensive sand and gravel deposits. At least a dozen small tributaries inflow from the north, the most significant of which is Elk Ravine, which drains the Lawrence Livermore Radiation Laboratory area. Two significant tributaries inflow from the south. The first from Mitchell Ravine drains the northern slope of Eagle Mountain. The second drains the northern face of the North Ridge area.

Rainfall in the watershed decreases as you move from west to east in the drainage basin. Rainfall ranges from near 20 inches in the higher elevations near Mt. Wallace to 8 inches or less near Interstate Highway 580. Rainfall patterns are influenced by two factors: the west-to-east storm track and the changes in elevation. The highest rainfall amounts are found near the high-elevation areas in the southern extreme of the watershed but decrease as you move north. This is likely due to the influence of the lower-elevation Altamont Pass, which forms the northern

Figure A-7. Location of the Corral Hollow Creek Watershed in Alameda and San Joaquin Counties.



boundary of the drainage basin. Rainfall decreases also as you move into the lower-elevation areas of the eastern part of the drainage basin.

Vegetation in the watershed follows the rainfall patterns. Hardwood forests intermingled with grasses are extensive in the upper watershed especially above the 2,000-foot elevation. Chaparral and Mountain Brush exist in pockets at the highest elevations near Mt. Boardman and Mt. Wallace. Hardwood forest only appears on the northern exposure slopes where elevations drop below 2,000 feet. The hardwood areas are rarely found below 1,500-foot elevation. The entire northern and eastern portions of the watershed are covered with grasses and forbes. Cattle grazing is extensive in the area.

Water quality in the creek is not influenced by discharge activities in the drainage basin. Cattle-watering ponds are extensive in the area. Water quality sampling was conducted on Corral Hollow Creek at a point about 1.5 west of Interstate Highway 580. In addition, periodic stream sampling for mineral water quality has been conducted by both the California Department of Water Resources and the United States Geological Survey. The three sampling programs show a median salinity and boron concentration of 2,000 μmhos/cm and 4.7 mg/L, respectively (Table A-12). Although the boron concentrations are elevated for such a large watershed, the limited trace-element testing conducted showed low selenium and molybdenum concentrations. Median selenium and molybdenum concentrations were 1.0 and <5 μg/L, respectively (Table A-13).

12. DEEP GULCH CREEK (San Joaquin County)

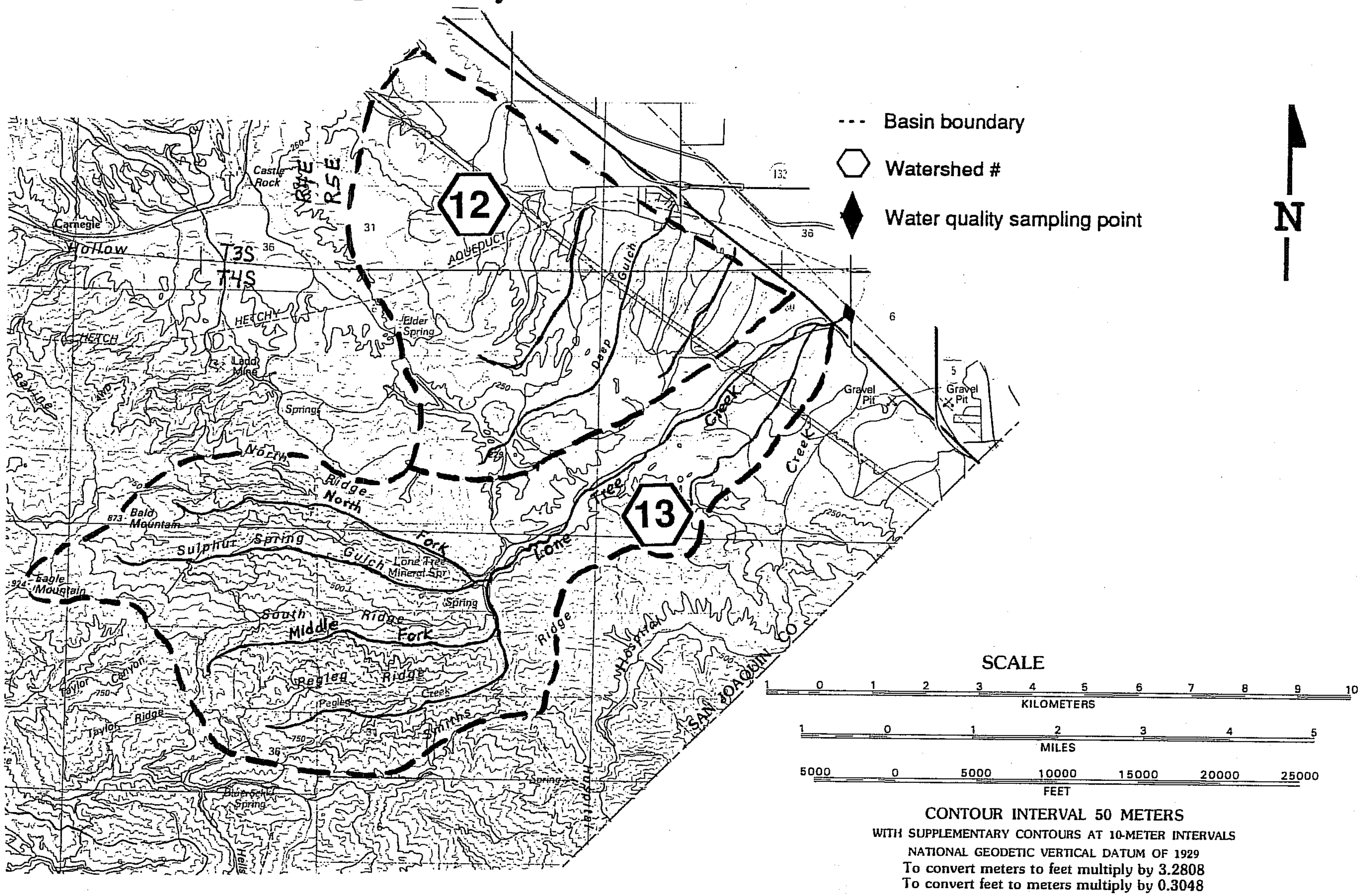
Deep Gulch Creek is one of six very small creeks that drain a low elevation area between Corral Hollow and Lone Tree Creeks. The drainage area covers 15.8 square miles (Figure A-8). Deep Gulch Creek is representative of the other creeks and covers about 1/3 of the drainage area. Elevation ranges from a maximum of 1,400 feet above sea level to approximately 300 feet where these streams pass under Interstate Highway 580.

The topography in the watershed is low hills in the west with elevations between 800-1,400 feet above sea level. As you move east, these turn into gently rolling hills, which drop abruptly to the valley floor. There are only isolated areas in the watershed above 1,000 feet elevation.

Rainfall in the area of these 6 streams varies from 10 inches at the higher elevations to less than 8 inches in the east. The entire watershed is covered with grasses and forbes. Cattle graze in the area.

No known discharges occur in the drainage basin that would impact stream water quality. No water quality sampling has been conducted in this watershed.

Figure A-8. Location of the Deep Gulch Watershed Area and the Lone Tree Creek Watershed in San Joaquin County.



13. LONE TREE CREEK (San Joaquin County)

The Lone Tree Creek watershed is small watershed that is wedged between two distinct ridges. Lone Tree Creek watershed covers approximately 22.6 square miles (Figure A-8). Elevation ranges from a maximum of 2,865 feet above sea level near Bald Mountain in the western portion of the watershed to less than 400 feet near the water quality sampling point where the creek crosses under Interstate Highway 580.

Topography in the watershed is dominated by a series of ridges that strike east to west axis. The entire watershed is wedged between two ridges that form the north and south boundaries of the drainage basin. North Ridge, a series of hills with an average elevation of 2,000 feet above sea level makes up the northern boundary. A similar but slightly higher ridge, Smith's Ridge, makes up the southern boundary with the Hospital Creek watershed. The west boundary, along the Corral Hollow Creek watershed, is a series of higher mountains including Bald (2,865 MSL) and Eagle (3,033 MSL) Mountains. The western portion of the Lone Tree Creek watershed is made up of four tributaries (North Fork, Sulphur Springs Gulch, Middle Fork and Pegleg Creek) that form together to make the main branch of Lone Tree Creek. Each of the tributaries flow west to east through a series of ridges that also have a west to east axis. The two most prominent ridges are the South and Pegleg Ridge. All the ridges have maximum elevations near 2,000 feet above sea level. After the confluence of the four tributaries near 800 feet elevation, Lone Tree Creek Flows through a broad stream valley 6-7 miles to a point at the 400-foot elevation where it enters the San Joaquin Valley floor.

Rainfall varies from near 16 inches in the western portion of the drainage basin to less than 8 inches where it enters the valley floor near Interstate Highway 580. Vegetation patterns in the basin follow rainfall patterns, but also closely follow the slope and slope exposure. The upper portions of the watershed are covered with extensive areas of Pinon-Juniper forest. These areas mostly predominate on the northern-facing slopes of the east-west lying ridges. Few of these areas are found below 1,200 feet in elevation. The Pinon-Juniper area have hardwood tree and grass areas interspersed in it. The eastern portion of the watershed, especially east of the tributary confluence, is made up almost entirely of grasses and forbes. Cattle grazing is extensive through the watershed.

There are few cattle-watering ponds in the basin; however, several windmills to pump shallow ground water have been operated in the basin. There are no known discharges that would impact water quality. Water quality sampling was conducted on Lone Tree Creek at a point near where it passes under Interstate Highway 580. In addition, one sample each has been collected by the United States Geological Survey and the California Department of Water Resources. The limited number of samples collected on this stream shows median salinity and boron concentrations of 1,475 μmhos/cm and 2.9 mg/L, respectively (Table A-14). The median selenium concentration for this sampling period showed 1.7 μg/L (Table A-15).

14. HOSPITAL CREEK (San Joaquin and Stanislaus Counties)

Hospital Creek is an extensive watershed that covers approximately 36.2 square miles (Figure A-9). Elevation ranges from a maximum of 3,347 feet above sea level near Mt. Oso in the southeast portion of the upper watershed to less than 300 feet near the water quality sampling point where the creek crosses under Interstate Highway 580.

The topography in the watershed varies from high peaks and steep slopes in the upper watershed to low hills in the eastern portion. The upper watershed of Hospital Canyon is ringed by a ridge line that has elevations in excess of 2,600 feet above sea level. The highest points along this ridge line are in excess of 3,000 feet with Mt. Oso (3,347 MSL) dominating the eastern boundary of the ridge and Mt. Hospital (3,285 MSL) dominating the southern ridge line. The western ridge of the upper watershed is dominated by the eastern slopes of Mt. Boardman (3,593 MSL). Flow from the western ridge produces the West Fork of Hospital Creek, which is the only main tributary in the upper watershed. A lesser tributary flows from Buckeye Cluch. The area downstream of the West Fork confluence is made up of low hills with elevations generally less than 1,500 feet above sea level.

Rainfall in the watershed varies from greater than 18 inches near Mt. Boardman in the western portion of the watershed to less than 8 inches where it enters the valley floor near Interstate Highway 580. Vegetation patterns in the basin follow rainfall patterns. In the upper elevations, hardwood tree areas are extensive, but an extensive area of the upper watershed, especially on the north-facing slopes, have large areas of Pinon-Juniper forests. These areas give way to a zone of northern desert shrubs or coastal sagebrush in zones with an elevation from 1,200-2,000 feet above sea level. Isolated pockets of chaparral and mountain brush exists at elevations higher than 2,000 feet in the Mt. Boardman area. All of these areas have grass interspersed among them. The eastern portion of the watershed, especially in areas where rainfall is less than 12 inches, are made up almost entirely of grasses and forbes. There are isolated areas of hardwood trees, but these are scattered and are only seen on the north facing slopes above 800-1,000 feet in elevation. Cattle grazing is extensive through the area.

There are no known discharges that would impact water quality. The Buckeye Mines are present in the Buckeye Gulch, but no inspection has been made of these facilities. There are few cattle-watering ponds in the drainage basin; however, several windmills to pump shallow ground water have been operated in the basin. The lower portion of the watershed enters a broad flood plain valley that is characterized by a high percentage of gravel and sand. Flow in the creek in this portion is often underground, reappearing further downstream. Several sand and gravel mining operations have been operated in the lower portions of the watershed.

Water quality sampling was conducted on Hospital Creek at the point immediately upstream of where the creek passes under Interstate Highway 580. In addition, the United States Geological Survey sampled this site for mineral water quality once in 1956. From the limited water quality

Figure A-9. Location of the Hospital Creek Watershed in San Joaquin and Stanislaus Counties

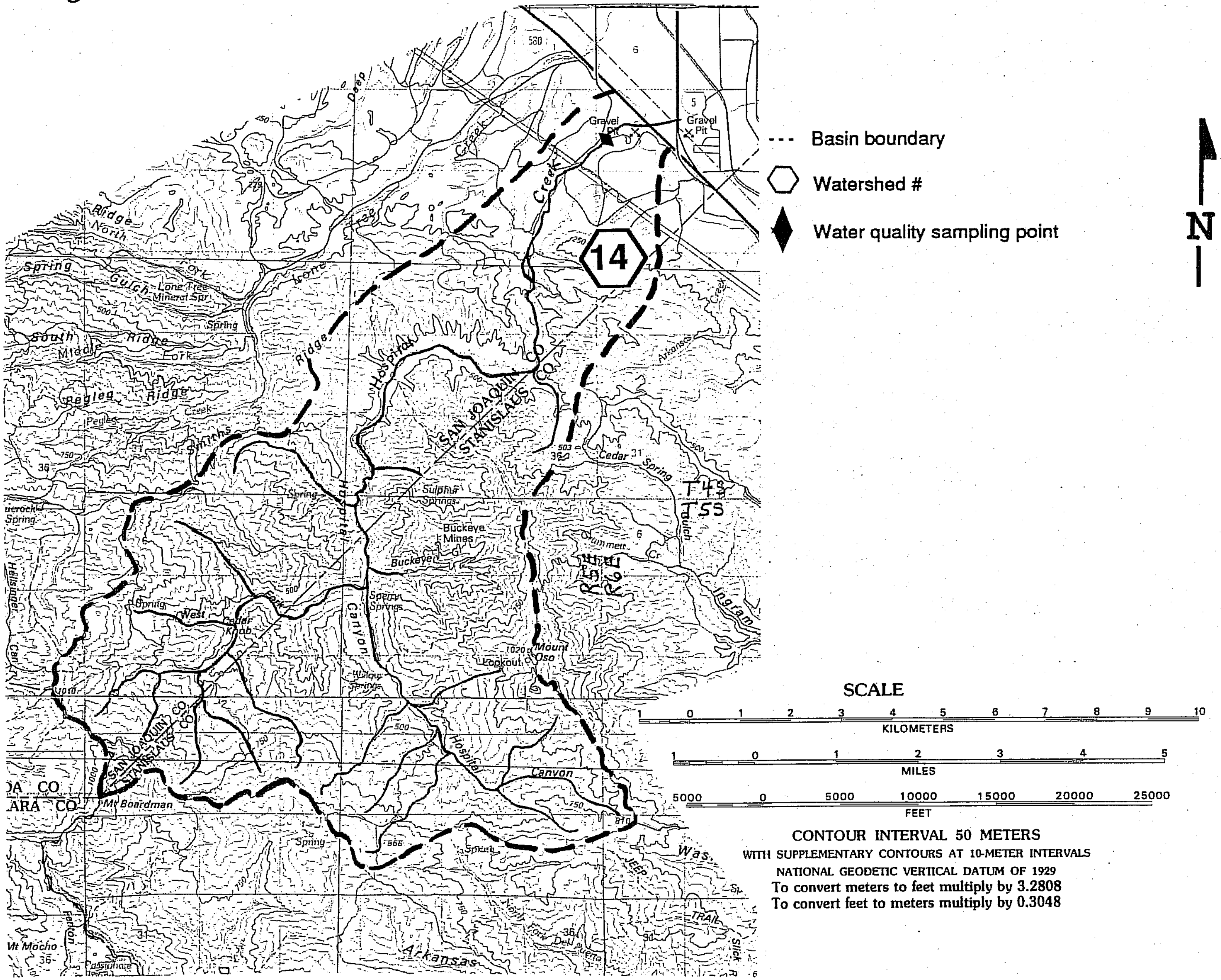
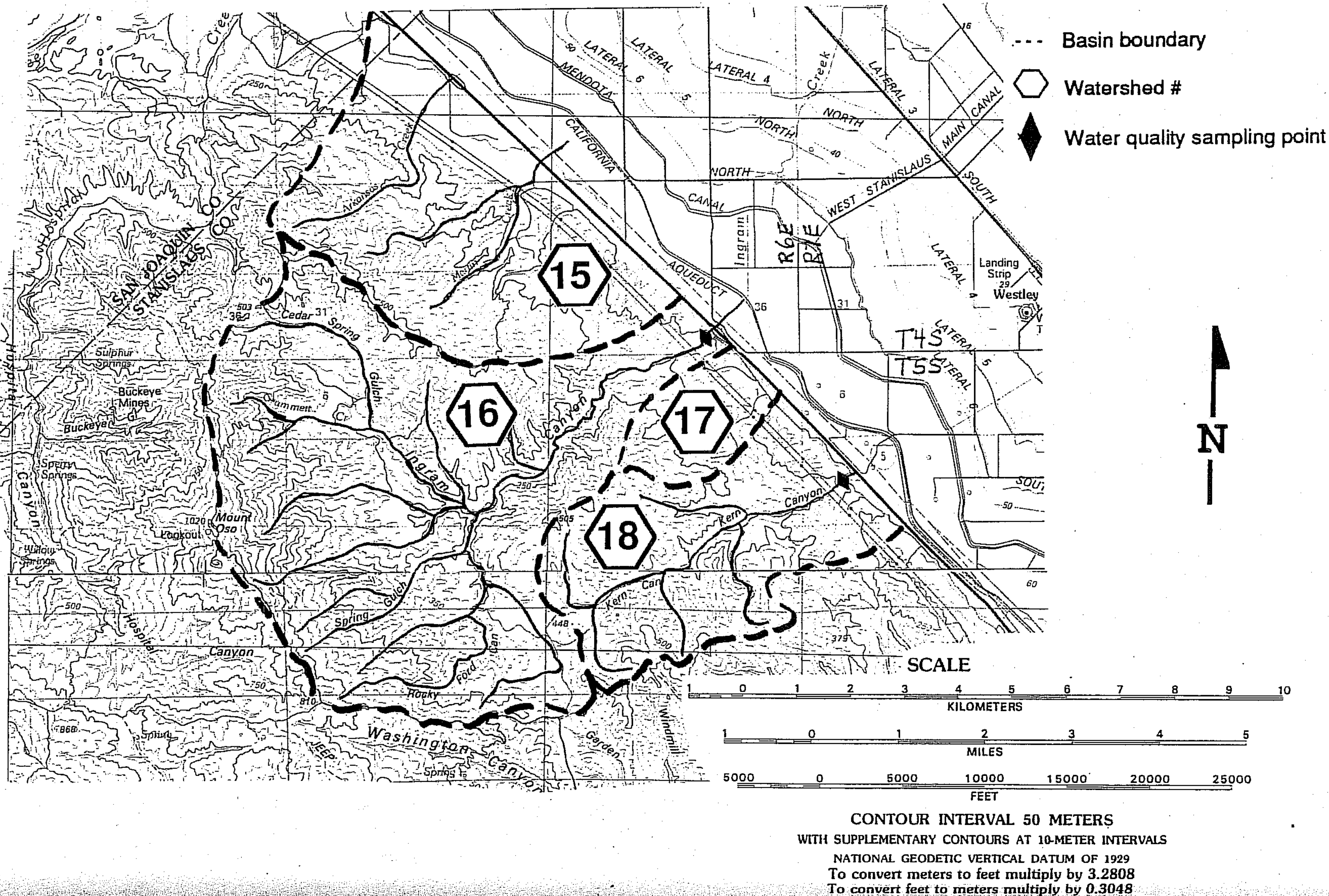


Figure A-10. Location of the Ingram Creek and Kern Creek Watersheds and the Arkansas-Martin Creek and the Mile 33 Creek Drainage Areas in Stanislaus and San Joaquin Counties.



data available, median salinity and boron concentrations are 855 μmhos/cm and 0.94 mg/L, respectively (Table A-16). The low salinity and boron concentrations are also reflected in consistently low selenium and molybdenum concentrations. The median selenium and molybdenum concentrations are 1.0 and <5 μg/L, respectively (Table A-17).

15. ARKANSAS-MARTIN CREEK AREA (San Joaquin and Stanislaus Counties)

Arkansas and Martin Creeks are two of four very small creeks that drain a low-elevation area between Hospital and Ingram Creeks. The drainage area covers 12 square miles (Figure A-10). The two main creeks are representative of the other creeks and cover about 2/3 of the drainage area. Elevation ranges from near 1,900 feet along the western boundary to less than 300 feet above sea level where these streams enter the valley floor and pass under Interstate Highway 5.

The topography in the watershed is low, steep hills in the west with elevations between 1,400 and 1,975 feet above sea level. These hills drop steeply to the east and abruptly drop to the valley floor. Changes in elevation from greater than 1,700 feet to 300 feet often occur in vertical distances of 2-3 miles.

Rainfall in the watershed area of the four creeks varies from near 10 inches in the west to less than 8 inches in the east. The entire watershed is covered with grasses and forbes. Cattle grazing is extensive in the area.

No discharges occur in the drainage basin that would impact water quality. A cogeneration power unit is located in the basin, where used tires are burned to produce electrical power. Cooling water from this facility is discharged to ponds in the area. No water quality sampling of streamflow has been conducted in these watershed.

16. INGRAM CREEK (Stanislaus County)

Ingram Creek is a small watershed which is dominated by high-elevation areas in its upper watershed. Ingram Creek drainage basin covers 20.4 square miles (Figure A-10). Elevation ranges from 3,347 feet at Mt. Oso to less than 300 feet near the water quality sampling point where the creek passes under Interstate Highway 5.

The topography in the watershed varies with high slopes in the upper watershed and low steep hills in the eastern or lower portion of the watershed. The upper watershed is ringed on the west and south by high ridges that separate it from the Del Puerto Creek drainage to the south and the Hospital Creek drainage to the west. The southern ridge varies from 2,300-2,600 feet above sea level while the western ridge is dominated by the high slopes of Mt. Oso. This entire area is drained by several smaller tributaries which converge prior to flowing in an eastward direction. Ingram Creek then flows in a flood plain that is surrounded by several steep sloped hills with elevations often exceeding 1,000-1,500 feet.

Rainfall in the drainage basin ranges from 12 inches near Mt. Oso to less than 10 inches in the eastern extremes of the watershed. The upper portions of the watershed are dominated with hardwood trees interspersed with grasses. Isolated areas of pinon-juniper forest exist on the slopes of Mt. Oso along with pockets of chaparral and mountain brush. In the lower elevations, pockets of coastal sagebrush exist, but the majority of the watershed area below an elevation of 1,000-1,500 feet is grasses and forbes. Cattle grazing is extensive in the area.

Several small stock-watering ponds or reservoirs (<50 acre foot) have been constructed in the drainage basin. No discharges occur that might impact water quality. Water quality sampling was conducted on Ingram Creek at a point just prior to the creek passing under Interstate Highway 5. In addition, the United States Geological Survey did a one-time sampling of Ingram Creek in 1956. From the limited data base available, median salinity and boron concentrations are 2,000 μmhos/cm and 6.0 mg/L, respectively (Table A-18). The elevated boron concentrations measured in this stream are also reflected in elevated selenium concentrations. The median selenium and molybdenum concentrations from the present data base are 4.3 and <5 μg/L, respectively (Table A-19).

17. MILE 33 CREEK (Stanislaus County)

Mile 33 Creek is a very small watershed between Ingram and Kern Creeks. The watershed covers only 1.6 square miles (Figure A-10). Elevation ranges from near 1,370 feet above sea level to less than 300 feet where the creek passes under Interstate Highway 5 at the Mile 33 point on the California Aqueduct.

Topography is low hills with steep slopes to the east. Rainfall averages about 9 inches per year with vegetation being solely grasses and forbes.

No discharges occur in this basin that would impact water quality. No water quality sampling was conducted in this watershed.

18. KERN CREEK (Stanislaus County)

Kern Creek is a small, low elevation watershed immediately north of the Del Puerto Creek drainage basin. The watershed covers 6.1 square miles (Figure A-10). Elevation ranges from 1,800 feet above sea level to less than 300 feet where the creek enters the valley floor and passes under Interstate Highway 5.

Topography varies only by elevation in the watershed. Steep sloping hills ring the watershed on the north, west and south. Elevation approaches 1,800 feet in the south but generally ranges from 1,500-1,600 feet in the west and north. As the creek flows east, it moves through a small flood plain canyon bordered by steeply sloping hills.

Rainfall does not vary greatly in the drainage basin and averages about 10 inches. Vegetation is predominantly grasses and forbes, but isolated pockets of coastal sagebrush occur in the upper elevations. These isolated pockets cover 25-30 percent of the watershed. Cattle grazing occurs extensively in the watershed.

No discharges occur that would impact water quality. Water quality sampling was conducted on Kern Creek immediately upstream of the irrigated agricultural fields at the mouth of Kern Canyon. During this limited sampling period, median salinity and boron concentrations were 5,750 μmhos/cm and 10 mg/L, respectively (Table A-20). In addition to the elevated concentrations of salt and boron, elevated selenium concentrations were also noted. The median selenium concentration was 6.5 μg/L (Table A-21).

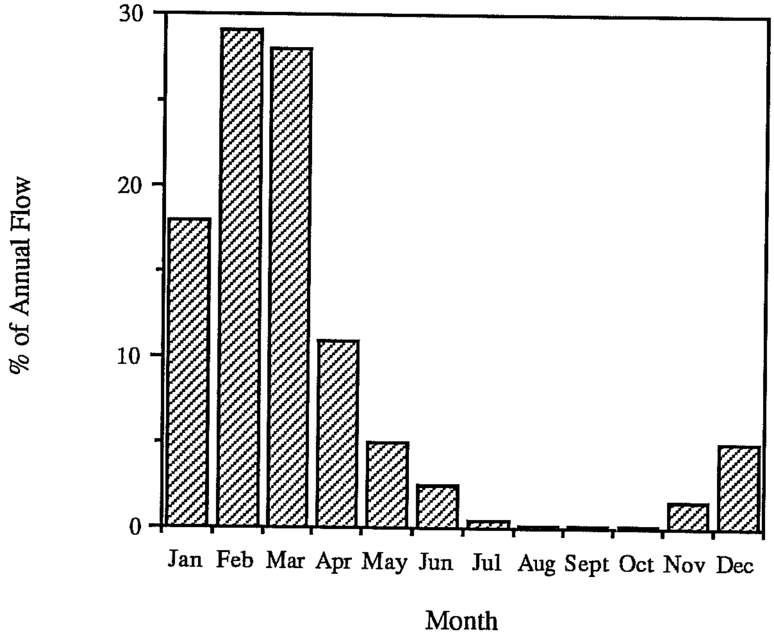
19. DEL PUERTO CREEK (Stanislaus County)

Del Puerto Creek is the second largest watershed in the middle study group. The watershed covers 76.2 square miles (Figure A-11) above the point where it passes under Interstate Highway 5. Del Puerto Creek originates on the southern slopes of Mt. Boardman (3,593 MSL) and the crest of the Coastal Range. The drainage basin although extensive, is long and relatively narrow as it flows in a west to east direction. Elevation ranges from near 3,600 feet above sea level to less than 200 feet near the water quality sampling point where the creek crosses under Interstate Highway 5.

The topography of the watershed is dominated by a series of high ridges that act as the northern, western and portions of the southern boundary of the drainage basin. The western boundary is dominated by Mt. Boardman in the north dropping to a ridge with elevations greater than 3,000 feet above sea level. The western ridge line continues south past the Red Mountain area (3,654 MSL) to a point where the ridge line is broken at 2,385 feet above sea level where the Del Puerto Canyon Road crosses over to the western coastal range drainage basins. This is the first road that crosses the drainage divide south of the Altamont Pass. After the low Del Puerto Canyon Road pass the ridge line turns in an eastern direction and continues past the Adobe Peak area (3,121 MSL) at an elevation near or above 3,000 feet. The ridge line forms the southern boundary of Adobe Canyon and continues to the Copper Mountain area (2,678 MSL). From the Copper Mountain area the ridge line begins a general elevation decline toward the east until it forms into a series of steep hills in the eastern portion of the watershed. A similar declining, yet slightly higher ridge line runs along the northern boundary of the basin. This ridge forms the southern boundary of the Hospital Creek and Ingram Creek watersheds.

Peach Tree and Adobe Canyon form the two principal tributaries from the south while Deer Park Canyon Creek is the major northern branch from the slopes of Mt. Boardman. After the confluence of Deer Park Canyon, the North Fork Del Puerto Creek and Washington Canyon Creek are the only significant tributaries.

Figure A-12 Distribution of Streamflow Throughout the Year for Del Puerto Creek Based Upon a 25-Year Period of Record (1965-present).



Rainfall in the watershed is strongly influenced by topography. Rainfall exceeds 17 inches in the western portions of the watershed but drops to 9 inches or less in the extreme eastern portions of the watershed. The majority of the Del Puerto Creek stream flow originates in the western portion of the drainage basin, especially in the higher elevation areas of the extreme western portion. USGS (1985) records indicate that the maximum flow rates as the creek crosses under Interstate Highway 5 have been near 1,800 cfs, but there are many days, especially in summer when there is no flow being recorded. The average annual discharge for the 25-year period of record (1965-present) is 5,270 acre-feet. The average discharge varies from 34,560 to 21 depending upon the rainfall year. The average yield is approximately 73 acre-feet per square mile (Table 6). This is less than one-half the yield shown in Marsh Creek in the northern study group (see Watershed #4). The runoff is not uniform throughout the year. Heavy flows occur in the winter rainfall period with flows decreasing through spring and early summer months with some months showing no flow. Figure A-12 shows the average percentage of flow for each month for the 25-year period of record.

Figure A-11. Location of the Del Puerto Creek Watershed in Stanislaus County.

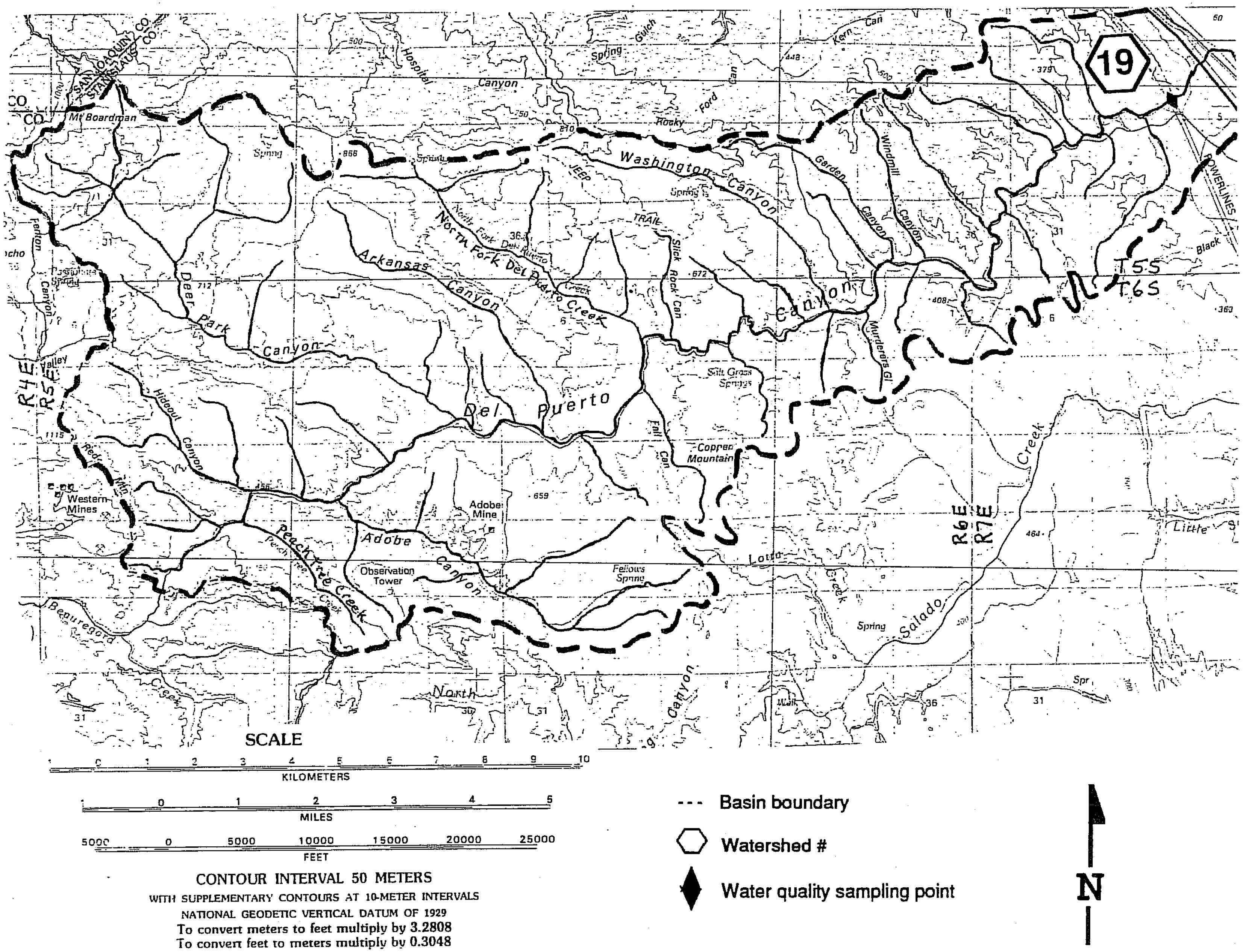
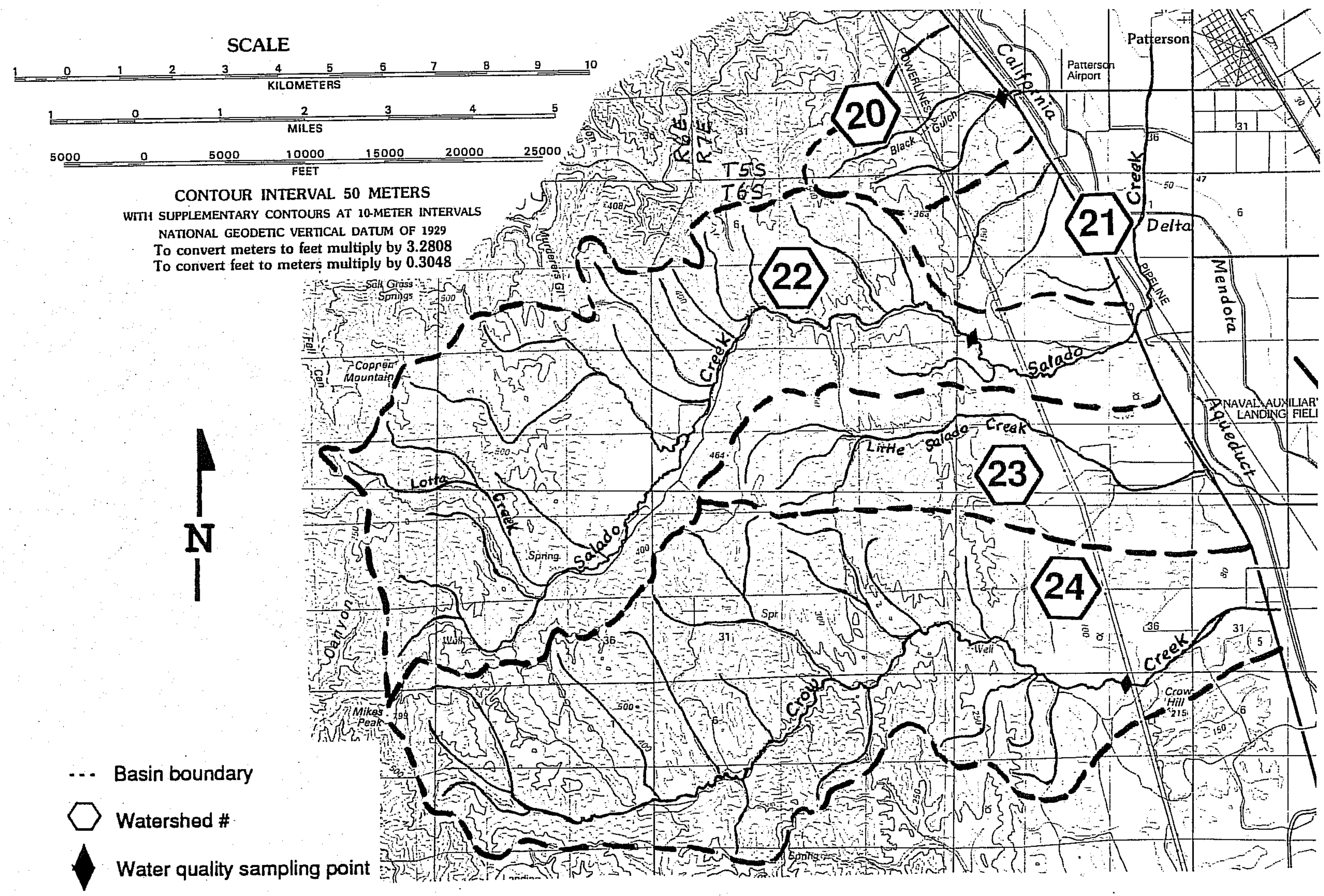


Figure A-13. Location of the Black Gulch, Salado, Little Salado and Crow Creek Watersheds and an Unnamed Watershed in Western Stanislaus County.



Vegetation in the watershed closely follows the rainfall and elevation patterns. The highest-elevation areas (above 2,000 feet) are covered with chaparral and mountain brush. The northern-facing slopes have a greater density than the hotter southern exposures. The middle half of the watershed has extensive hardwood tree areas interspersed with grasses. The hardwood areas likewise are more extensive on the northern exposure slopes. The lowest portion of the watershed (eastern portion) is covered with grasses and forbes including extensive areas of salt grass. Within the grass zone are also found isolated pockets of coastal sagebrush. Cattle grazing is seen throughout the area.

There are no discharges that would have an impact on water quality in the stream. A number of cattle-watering ponds are found throughout the area. Water quality sampling was conducted on Del Puerto Creek at a point near where the creek passes under Interstate Highway 5. In addition, periodic mineral water quality samples have been collected by both the California Department of Water Resources and the United States Geological Survey (USGS). The USGS continues to operate the flow measurement station at the water quality sampling site. The limited data base available shows median salinity and boron concentrations of 1,350 µmhos/cm and 1.6 mg/L, respectively (Table A-22). The median selenium and molybdenum are low; 0.6 and <5 µg/L, respectively (Table A-23).

20. BLACK GULCH CREEK (Stanislaus County)

Black Gulch Creek is a very small, low-elevation watershed immediately south of the Del Puerto Creek watershed. The watershed covers 3 square miles (Figure A-13). Elevation ranges from near 1,800 feet above sea level to less than 250 feet where the creek enters the valley floor and passes under Interstate Highway 5.

Topography is dominated by steep sloping hills in the western portion of the watershed where elevations are above 1,500 feet and approach 1,800 feet above sea level. The steep sloping hills break into a series of rolling hills with elevations from 400-700 feet above sea level. These rolling hills drop abruptly to the valley floor.

Rainfall in the drainage basin averages less than 10 inches. Vegetation is solely grasses and forbes with extensive areas of salt grass present. Cattle grazing is seen extensively throughout the area.

There are no discharges in the watershed. There are cattle-watering points that utilize windmills.

Water quality sampling was conducted on Black Gulch Creek at a point upstream of where the creek passes under Interstate Highway 5. The limited data base developed in this study shows median salinity and boron concentrations of 8,500 µmhos/cm and 4.5 mg/L, respectively (Table A-24). Although the salt concentrations were very high, the boron was only moderately elevated. Selenium and molybdenum concentrations, however, were strongly elevated. The median concentrations for selenium and molybdenum were 20 and 11 µg/L, respectively (Table A-25).

21. UNNAMED CREEK (Stanislaus County)

The unnamed creek area consists of three very small watersheds between Black Gulch and Salado Creeks. The watershed covers 3.7 square miles (Figure A-13). Elevation ranges from near 1,000 feet above sea level along the western boundary to less than 250 feet where these creeks pass under Interstate Highway 5 at a point south of mile 40 on the California Aqueduct.

Topography is low rolling hills that drop abruptly to the valley floor. Rainfall averages about 9 inches per year with vegetation being solely grasses and forbes. Cattle grazing occurs extensively throughout the area.

No discharges occur in this basin that would impact water quality. No water quality sampling has occurred in the watershed.

22. SALADO CREEK (Stanislaus County)

Salado Creek is a low-elevation watershed that covers approximately 25.6 square miles (Figure A-13). Elevation ranges from a maximum of 2,678 feet above sea level at Copper Mountain in the western portion of the watershed to less than 250 feet where the creek crosses under Interstate Highway 5.

The topography in the watershed varies. The western boundary is a high ridge extending from Copper Mountain (2,678 MSL) south to the vicinity of Miles Peak (2,620 MSL). The north and south boundaries of the watershed then slope eastward with elevations ranging from 1,000-1,300 feet above sea level. The creek flood plain is very wide and does not have an extensive grade.

Rainfall in the basin varies from an average of near 14 inches in the western portions to less than 9 inches at the extreme eastern boundary of the basin. Vegetation in the watershed reflects the low rainfall. Areas of hardwood trees interspersed with grasses make up much of the upper watershed especially above the 2,000-foot elevation. The majority of the watershed is grasses and forbes with areas of coastal sagebrush interspersed in the grass zone. Hardwoods are also found below the 2,000-foot elevation, but they are usually found on the north facing slopes.

There are no discharges that would impact water quality. Cattle grazing is extensive throughout the watershed, and a number of small reservoirs have been constructed for cattle watering including reservoirs on a few of the tributaries. Irrigated cropping is conducted in the extreme eastern portion of the watershed with imported Delta water. Runoff from this area does impact water quality; therefore, water quality sampling was done upstream of this area.

Water quality sampling was conducted on Salado Creek at a point upstream of the irrigated areas in the basin. The limited data base developed in this study shows median salinity and boron concentrations of 2,600 μmhos/cm and 1.6 mg/L, respectively (Table A-26). Although the salinity and boron concentrations are low compared to other smaller streams, selenium concentrations are slightly elevated. The median concentrations for selenium and molybdenum are 3.9 and <5 μg/L, respectively (Table A-27).

23. LITTLE SALADO CREEK (Stanislaus County)

Little Salado Creek is a small, low-elevation watershed immediately south of the Salado Creek watershed. Little Salado Creek watershed covers approximately 9.1 square miles (Figure A-13). Elevation ranges from 1,760 feet above sea level in the western extreme of the watershed to less than 250 feet where the creek cross under Interstate Highway 5.

The topography varies from a series of steep hills in the west (near 1,600 feet elevation) dipping quickly to rolling hills. The extreme eastern portion of the basin is irrigated agricultural land.

Rainfall varies from an annual average of 9 to 11 inches depending upon elevation in the watershed. Vegetation is principally grasses and forbes, but isolated areas of hardwood trees exist on the northern slopes of the highest elevation areas. Cattle grazing is extensive throughout the watershed.

No discharges occur in the watershed; however, runoff from the irrigated area can impact natural stream quality and flow. No water quality sampling was conducted in this watershed.

24. CROW CREEK (Stanislaus County)

Crow Creek is a long, narrow, low-elevation watershed that covers approximately 28.4 square miles (Figure A-13). Elevation ranges from a maximum of 2,620 feet above sea level at Miles Peak in the western portion of the watershed to less than 250 feet where is crosses under Interstate Highway 5.

Topography varies with steep hills extending along the western and a portion of the southern boundary. The northern and south boundaries of the watershed slope eastward with elevations ranging from 1,000-1,600 feet above sea level. The creek follows a wide flood plain.

Rainfall in the basin varies from an average of near 14 inches in the western portions to less than 10 inches in the extreme eastern boundary of the basin. Vegetation in the watershed reflects the low rainfall. The upper or western portion of the watershed is an area of hardwood trees interspersed with grasses. The hardwoods predominate on the northern exposure slopes while grasses predominate on the southern ones. At elevations below 1,500 feet, grasses and forbes predominate. Cattle grazing is extensive throughout the watershed.

No discharges occur in the watershed; however, the extreme eastern portion of the watershed is in irrigated agriculture where runoff from the imported Delta water can impact natural stream quality. Water quality sampling was done above this point. There are also several stock-watering reservoirs and ponds constructed in the watershed.

Water quality sampling was conducted on Crow Creek at a point upstream of the irrigated area. The limited data base developed in this study shows median salinity and boron concentrations of 4,800 µmhos/cm and 2.2 mg/L, respectively (Table A-28). The salinity is moderately elevated; as well, the selenium concentrations are also moderately elevated. Median concentrations of selenium and molybdenum were 8.0 and <5 µg/L, respectively (Table A-29).

25. INTERFAN CREEKS (Stanislaus County)

The Interfan creeks drain the low-elevation Crows Hill area immediately north of the Orestimba Creek drainage. The interfan area consists of three very small drainage basins that cover approximately 4 square miles (Figure A-14). Elevation ranges from 706 feet at Crows Hill to less than 250 at the eastern boundary of the watershed. Topography is low rolling hills that drop abruptly to the valley floor. Rainfall averages about 8-9 inches per year with vegetation being solely grasses and forbes. No water quality sampling has been conducted in these watersheds.

26. ORESTIMBA CREEK (Stanislaus County)

Orestimba Creek is the largest watershed in the middle study group. The watershed covers 141 square miles (Figure A-14) above the point where it passes under Interstate Highway 5. Elevation ranges from 3,804 feet above sea level at Mt. Stakes along the western boundary to less than 200 feet where the creek passes under Interstate Highway 5.

Orestimba Creek originates along an extensive area of the crest of the Coast Range. The creek is fed by both a North and South Fork. The North Fork drains the western ridge line south to Black Mountain near the 3,600-foot elevation and the north ridge boundary with the Del Puerto Creek watershed east to the Miles Peak area (2,620 MSL). The North Fork Drains in a steep creek canyon.

The South Fork originates in a high plateau area (Mustang Flat) in the southeast corner of the drainage basin. Three significant tributaries inflow to the South Fork prior to it joining the North Fork. The first is Red Creek, which drains the Bear Mountain area (2,604 MSL), a series of ridges that range in elevation from 2,200-2,500 feet above sea level. The second tributary, the Robinson-Pinto Creek drainage basin drains the southern slopes of Mt. Stakes. The third and smallest tributary is Sheep Thief Creek, which drains the eastern slopes of both Mt. Stakes and Black Mountain. The North and South Forks come together near Jackass Flat at the base of Wilcox Ridge, one of several high plateau ridges that are widespread in the upper Orestimba Creek watershed. After the confluence, Orestimba Creek flows in an eastward direction with lesser tributaries entering after draining the Wilcox Ridge (2,100-2,200 MSL), Orestimba Peak (2,074 MSL) and the Black Mountain (2,268 MSL) areas. The stream bed in the lower watershed is very wide and considerable sand and gravel deposits exist along the stream.

Rainfall in the watershed is strongly influenced by topography. Average annual rainfall ranges from 18 inches or greater in the higher elevation areas to 10 inches in the eastern extreme of the basin. The majority of the Orestimba Creek watershed is near the western crest (drainage divide); therefore, more than 65 percent of the watershed receives an annual rainfall in excess of 15 inches.

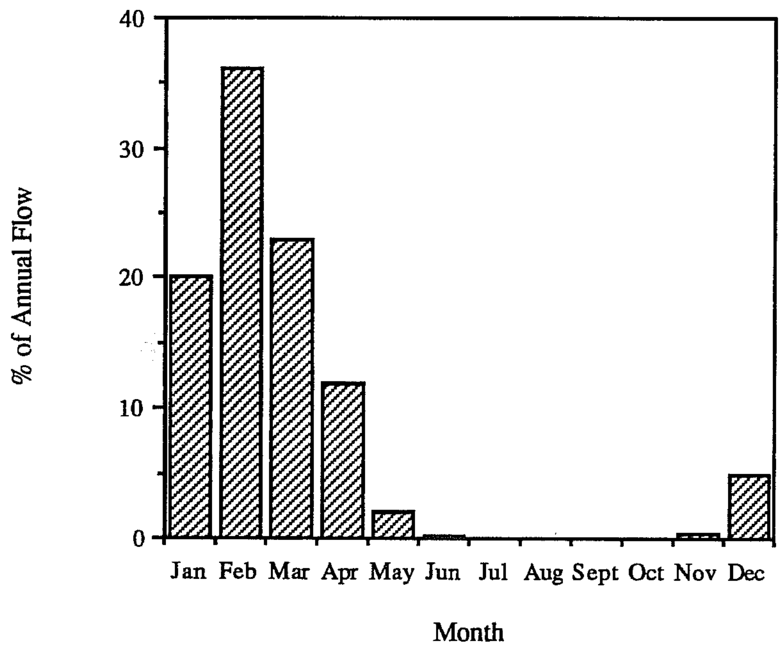
The majority of the Orestimba Creek streamflow originates in the western portion of the basin upstream of the Jackass Flat area. UGSS (1985) records indicate that the maximum flow rates as the creek crosses under Interstate Highway 5 have been in excess of 10,000 cfs, but there are many days, especially in summer when there is no flow being recorded. The average annual discharge for 59 years of record (1932-1990) is 12,320 acre feet per year. This average discharge has varied from 32,646 to zero depending upon the rainfall year, but the average yield is approximately 90 acre-feet per square mile. This is similar to Del Puerto Creek but less than half the yield found for Marsh Creek in the northern study area (Table 6). The slightly higher yield for Orestimba Creek as compared to Del Puerto Creek (73 acre feet per square mile) may be related to the greater percentage of higher elevation areas in the Orestimba Creek drainage basin.

Runoff is not uniform throughout the year. Heavy flows occur in the winter rainfall periods with flows decreasing through spring and early summer months with some months showing no flow. Figure A-15 shows the average percentage of flow for each month for the 59-year period of record.

Vegetation in the watershed follows the rainfall and elevation patterns. The highest elevations of the upper watershed (above 2,000 feet) are covered with chaparral and mountain brush. This vegetation is centered along the western ridge but predominates in the northwest portions near Mt. Stakes. Scattered pockets of chaparral and mountain brush exist along the southwest ridge, but in this high plateau area the predominant vegetation is hardwood forest areas interspersed with grasses. This vegetation makes up the main type for the high plateaus that are along the South Fork. The hardwood and grass interspersion continues until downstream of Jackass Flat and the Orestimba Narrows near Black Mountain. The lower elevation areas are covered extensively with grasses and forbes. Some of the high plateaus such as the Wilcox Ridge are covered with coastal sagebrush, but these are not extensive across the area. Cattle grazing is seen throughout the area.

There are no discharges that would impact water quality in the stream. A number of cattle-watering ponds are found throughout the area.

Figure A-15 Distribution of Streamflow Throughout the Year for Orestimba Creek Based Upon a 59-Year Period of Record (1923-1990).



Water quality sampling was conducted on Orestimba Creek at a point immediately upstream of where the California Aqueduct crosses the creek. In addition, both the United States Geological Survey and the California Department of Water Resources sampled this site for mineral water quality throughout the 1950s. From the combined data bases, median salinity and boron concentrations are 750 µmhos/cm and 0.32 mg/L, respectively (Table A-30). The low salinity and boron concentrations are also reflected in low trace element concentrations. Median selenium and molybdenum concentrations are 1.0 and <5µg/L, respectively (Table A-31).

27. BENNETT VALLEY CREEK (Stanislaus County)

Bennett Valley Creek drains a very small, low-elevation watershed that covers 6 square miles (Figure A-16). Elevation ranges from 500 feet above sea level to 200 feet where the stream crosses Interstate Highway 5.

Topography is very low rolling hills that become the valley floor to the east. Rainfall averages ten inches per year with vegetation being solely sparse grasses and forbes. Cattle grazing occurs in the area.

No discharges occur in the area, but care in water quality sampling must be taken as seepage from the California Aqueduct can impact natural stream water quality. No mineral water quality sampling has been conducted in this watershed. Only one sample for trace element concentrations has been taken from the creek just prior to the point where it passes under Interstate Highway 5. The single sample showed selenium at 11 µg/L and molybdenum at 116 µg/L (Table A-32).

28. GARZAS CREEK (Stanislaus County)

Garzas Creek is the fourth largest watershed in the middle study group. The watershed covers 57.3 square miles (Figure A-16) above where Garzas Creek passes under Interstate Highway 5. Elevation in the drainage basin ranges from near 2,600 feet above sea level in the western portion of the basin to less than 250 feet near the water quality sampling point where the creek crosses under Interstate Highway 5.

Topography in the watershed varies but generally reflects a narrow stream valley surrounded by high, steep ridge lines. Garzas Creek originates along a ridge line extending from Mustang Peak (2,263 MSL) in the west to Pine Springs Hill (2,386 MSL) in the east. This southern ridge has a general elevation near 2,000 feet above sea level. Garzas Creek flows in a north direction between two ridges. The western ridge from Mustang Peak to Zimba Peak (2,585 MSL) forms the western boundary of the drainage basin. The eastern ridge extends from Pine Springs Hill to Hamner Hill (2,429 MSL), which is about 2/3 of the length of the western ridge. The western ridge averages about 1,800 feet in elevation while eastern ridge is slightly higher at elevations in excess of 2,100 feet above sea level.

Beyond Hamner Hill, Garzas Creek makes a turn and begins an west to east flow direction. The creek canyon being bounded by two strong ridges. The southern ridge extends from the Pine Springs Hill-Hamner Hill ridge in an eastward direction past Eli hill (2,042 MSL) and Crevison Peak (2,109 MSL) then dropping in elevation to low steep hills in the eastern portion of the drainage basin. The northern basin boundary extends from Zimba Peak along the southern boundary of Orestimba Creek. Elevation on this ridge line drops as it moves east until it forms broad low hills near Oat Gulch Canyon.

Garzas Creek flows in a narrow steep stream canyon until it makes its turn to a west-east direction. The stream valley then becomes a wide flood plain valley.

Rainfall in the watershed decreases from west to east. Average annual rainfall exceeds 17 inches in the western portion of the watershed but drops to near 10 inches in the extreme eastern portion. Vegetation patterns follow the rainfall and elevation patterns in the basin. The upper basin from its origin to where it makes an eastward turn contains extensive areas of chaparral and mountain brush. Elevations below this have hardwood tree areas interspersed with extensive areas of grass. The eastern half of the basin has grasses and forbes as the dominant vegetation especially below an elevation of 1,200 feet. Cattle grazing is extensive through the basin.

There are no discharges to the creek that would impact natural water quality. There are extensive cattle-watering ponds and reservoirs in the drainage basin. The lower portion of the watershed is characterized by extensive areas of sand and gravel although no mining operations have been developed.

Limited water quality sampling was conducted on Garzas Creek during this study. In addition, both the United States Geological Survey and the California Department of Water Resources collected mineral water quality data in the late 1950's. This combined data base shows median salinity and boron concentrations of 740 μmhos/cm and 0.40 mg/L, respectively (Table A-33). The low salinity and boron concentrations were also reflected in low trace element concentrations. From the limited data base, median selenium and molybdenum concentrations were <1 and <5 μg/L, respectively (Table A-34).

29. MUSTANG CREEK (Merced County)

Mustang Creek is a very small, low-elevation watershed that covers 8 square miles (Figure A-17). Elevations in the watershed approach 1,400 feet above sea level and drop to less than 250 feet where the creek crosses Interstate Highway 5. The majority of the drainage basin, however, is steep low hills that rarely exceed 800-900 feet in elevation. These steep hills drop abruptly to the valley floor.

Rainfall in the basin averages about 10 inches per year. Vegetation reflects this low rainfall amount. The entire basin is covered with low grasses and forbes. Cattle grazing is extensive throughout the area.

There are no discharges which would impact natural stream quality. No water quality sampling has been conducted in this watershed.

30. QUINTO CREEK (Stanislaus and Merced Counties)

Quinto Creek is a small watershed that covers approximately 31.6 square miles (Figure A-17). Elevation ranges from near 2,400 feet above sea level in the western portions of the watershed to less than 250 feet where the creek crosses under Interstate Highway 5.

The topography in the watershed varies extensively. The drainage basin is a west to east flowing stream. The western portion of the drainage basin is a series of high ridge lines and peaks. Along the southern boundary, the slopes of Pine Springs Hill (2,386 MSL) are the origin of Quinto Creek. Extending eastward along the ridge, you encounter Bone Springs Hill (2,509 MSL) and further east Howard Peak (2,407 MSL). Along the northern boundary from Pine Spring Hill, you pass over Black Mountain (1,792 MSL), Eli Hill (2,042 MSL) and further east Crevison Peak (2,103 MSL). These ridge lines extend along the north and south boundaries of the watershed for slightly more than one-third the length of drainage basin. This upper one-third of the basin is the most significant for stream flow.

East of the high ridges, the ridge on both the north and south dips and becomes a series of low, steeply sloping hills in the eastern portion of the basin. In this lower two-thirds of the drainage basin, the creek flows in a wide flood plain valley with few significant inflows.

Figure A-16. Location of Bennett Valley Creek Area and the Garzas Creek Watershed in Stanislaus County.

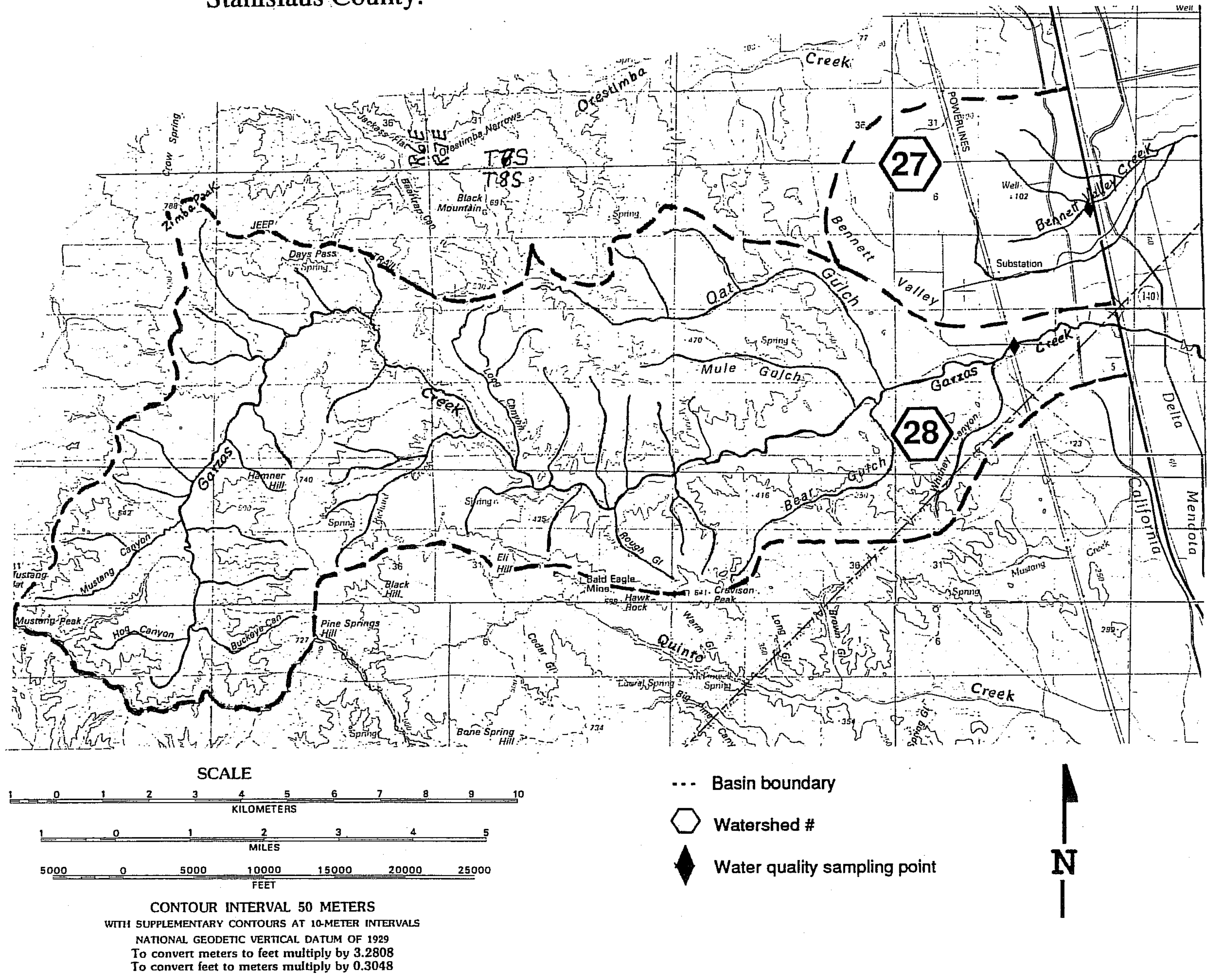
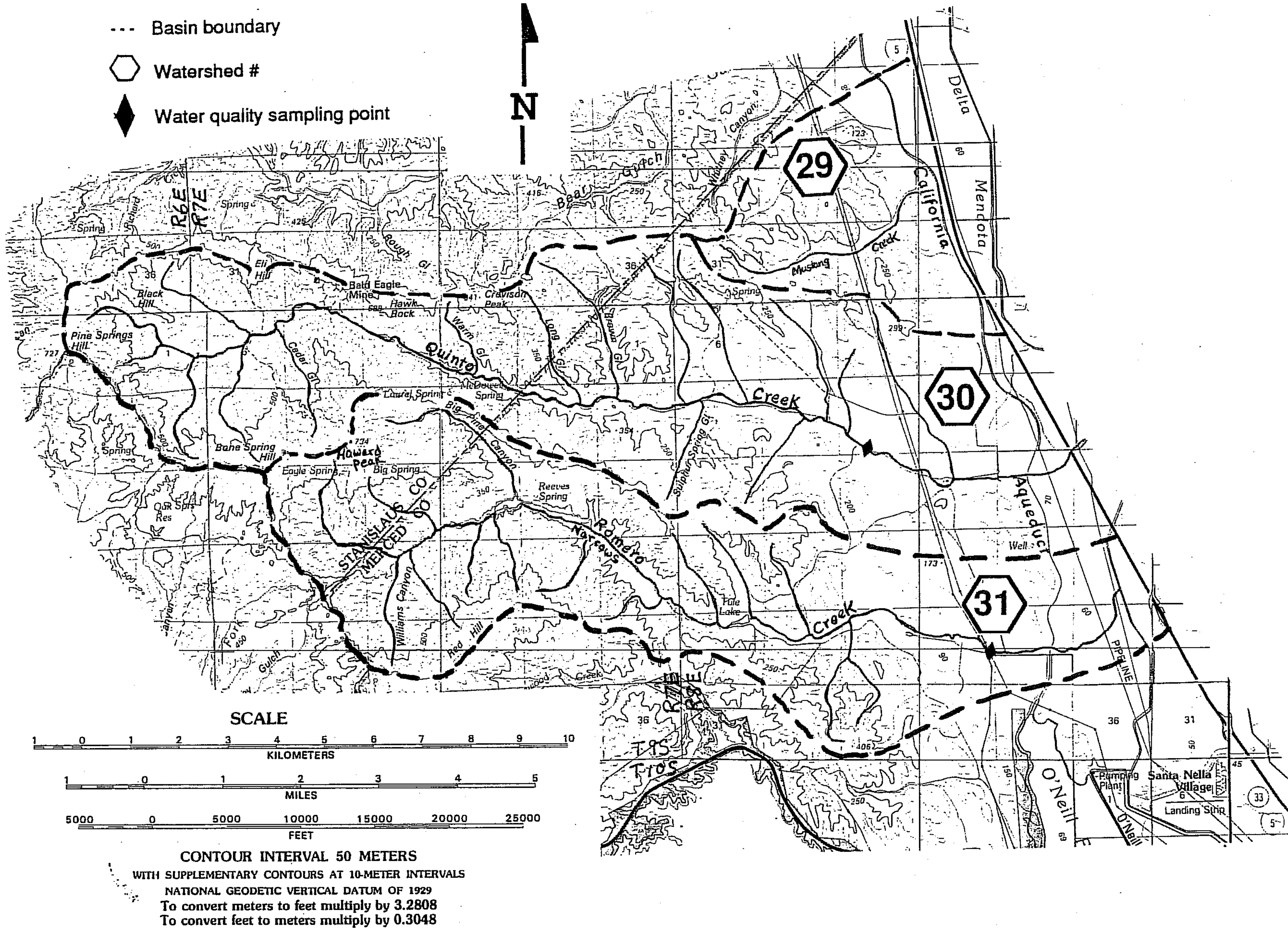


Figure A-17. Location of the Mustang Creek, Quinto Creek and Romero Creek Watersheds in Merced and Stanislaus Counties.



Rainfall in the watershed varies from greater than 16 inches in the upper watershed to less than 10 inches near the eastern boundary of the basin. Vegetation follows closely the west to east decline in rainfall and elevation. In the extreme western portion of the basin, isolated areas of chaparral and mountain brush exist. This transforms into extensive areas of hardwood trees interspersed in a grass zone. The hardwood areas are more extensive on the northern-facing slopes. The lower half of the basin, especially all areas below the 1,000-foot elevation, are covered extensively with grasses and forbes.

There are no known discharges that would impact water quality. The Bald Eagle Mine does exist in the basin, but no inspections of this abandoned facility have been made. Limited water quality sampling was conducted on Quinto Creek during this study. In addition, data collected by the United States Geological Survey during the early 1950's was used. This combined data base shows median salinity and boron concentrations of 940 μmhos/cm and 1.1 mg/L, respectively (Table A-35). From the limited data base, median selenium and molybdenum concentrations were <1 and <5 μg/L, respectively (Table A-36).

31. ROMERO CREEK (Stanislaus and Merced Counties)

Romero Creek is a small, low-elevation watershed that borders the Pacheco Pass (San Luis Reservoir) area. The watershed covers approximately 24.1 square miles (Figure A-17). Elevation ranges from near 2,500 feet above sea level in the western portion of the watershed to less than 250 feet, where the creek crosses under Interstate Highway 5.

The topography in the watershed varies. The drainage basin is a west to east flowing stream. The western one-third of the watershed is a higher elevation area with the lower two-thirds being a series of low steep hills that dip abruptly to the valley floor. Romero Creek originates on the southern slopes of the Bone Springs Hill (2,509 MSL) to Howard Peak (2,407 MSL) ridge and the northern slopes of the Red Mountain (2,402 MSL) area. These flows converge near an old dry lakebed area prior to the creek entering an area known as the Narrows. After the creek emerges from the Narrows, it flows into a wide flood plain valley characterized by Tule Lake, a shallow lakebed area. This area is surrounded by low steeply sloping hills. The creek then follows a wide flood plain valley before it moves into the valley floor.

Rainfall in the western portion of the basin averages 14 inches but drops as you move eastward to less than 8 inches near the valley floor. Vegetation in the basin is characteristic of this rainfall pattern. The higher-elevation areas and the northern-facing slopes of the southern ridge are covered with hardwood trees interspersed in grass. Extensive areas of grass and forbes cover the northern exposure slopes and the lower one-half of the watershed. Isolated pockets of coastal sagebrush exist on the higher slopes of Bone Springs Hill and the northern ridge above the Narrows.

There are no discharges that would impact water quality; however, the changes, as a result of the two small lakes in the basin, are unknown. Water quality sampling was conducted on Romero Creek during this study. The limited data base developed shows a median salinity and boron concentration of 1,000 µmhos/cm and 1.7 mg/L, respectively (Table A-37). The trace element concentrations were found to be low. From the existing data base, the median selenium and molybdenum concentrations were <1 and <5 µg/L, respectively (Table A-38).

32. LOS BANOS CREEK (Merced and San Benito Counties)

Los Banos Creek is the second largest watershed in the southern study area. The watershed covers 156 square miles (Figure A-18). The watershed area is equivalent to that of Orestimba Creek in the middle study group. Elevation ranges from 3,800 feet above sea level at Laveaga Peak along the western boundary of the watershed to less than 250 feet where the creek passes under Interstate Highway 5.

Los Banos Creek originates along an extensive area of the crest of the Coast Range. The creek is fed by both a North and South Fork. The North Fork drains a small area of very high peaks. Included in this small drainage basin are Mt. Ararat (3,274 MSL), Cathedral Peak (3,600 MSL) and Mariposa Peak (3,448 MSL) that form the northern boundary of the fork with Antimony Peak (3,297 MSL) and Peckham Peak (3,307 MSL) forming the western and southern boundaries, respectively. The North Fork flows in a west to east direction before joining the South Fork to continue a west to east flow direction.

The South Fork, prior to converging with the North Fork, flows in a south to north direction. The South Fork drains an extensive portion of the basin as it runs along the western drainage divide. The South Fork originates along the western and southern slopes of Bonanza Peak (3,718 MSL). As the South Fork drains north, it flows between two high ridges. Several small tributaries inflow from the Ortigalita Ridge (2,500-3000 MSL), which forms the eastern drainage divide while two significant tributaries enter from the high peak area along the western basin boundary. The first drains the Reinoso Peak (3,471 MSL) and Potrero Peak (3,745 MSL) slopes. The second, Rincon Creek, drains an extensive peak area dominated by the north slope of Potrero Peak, Laveaga Peak (3,801 MSL) and the southern slopes of Peckham Peak, which forms the drainage divide with the North Fork.

After the confluence of the two forks, Los Banos Creek flows into a broad flat high plateau valley (Los Banos Valley). Flow after the confluence is in a west to east direction. Flow from Los Banos Valley (600 MSL) then flows into Los Banos Reservoir, which has a spillway elevation of 354 feet above sea level.

Rainfall in the watershed reflects the relatively high ridge along the western boundary. Annual average rainfall exceeds 22 inches in the higher elevation areas but quickly decreases as you move eastward. Rainfall near the eastern boundary of the watershed only averages 8 inches. Rainfall throughout the South Fork drainage basin, however, exceeds 14 inches to a maximum in excess of 22 inches.

The majority of the Los Banos Creek streamflow originates in the North and South Forks especially in the higher elevation areas of the extreme western boundary. There are limited flow records on Los Banos Creek and daily flow records were only compiled for a short period of time; therefore, no estimate of the range of flow rates can be made. Good monthly and annual discharge records were compiled from the change in storage that has occurred in Los Banos Reservoir. The average annual discharge for a 23-year period of record (1967-present) is 12,200 acre-feet. The annual discharge in this period varied from 56,600 in 1983 to 900 acre-feet in 1977. The average yield is approximately 75 acre-feet per square mile, a value similar to that found in Del Puerto Creek (Watershed #19) and from Orestimba Creek (Watershed #26) (Table 6). This is less than one-half the yield obtained by Marsh Creek (Watershed #4) in the northern study group. As with other creeks in the study area, Los Banos Creek has heavy flows in the winter rainfall period with flows decreasing throughout spring and early summer months with some months showing no flow. Figure A-19 shows the average percentage of the annual flow for each month for the 23-year period of record.

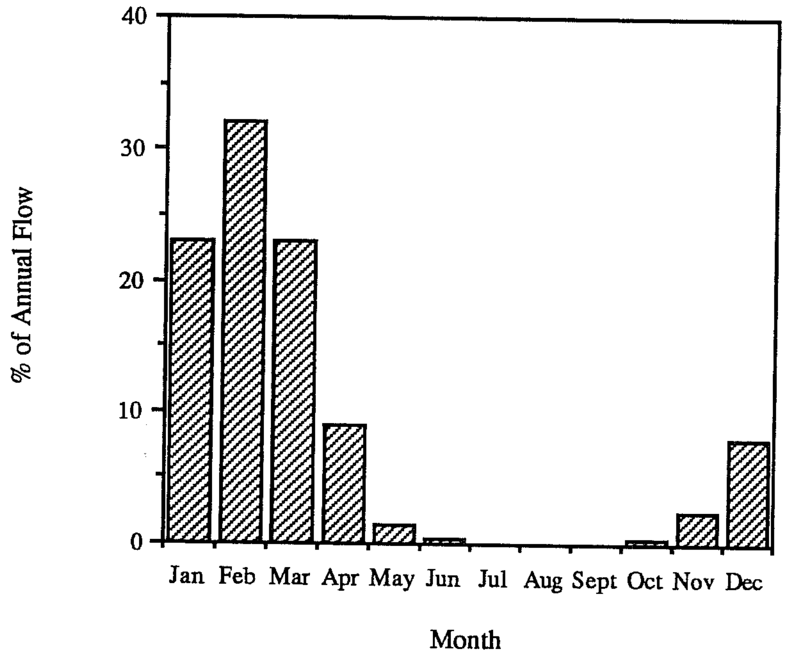
Vegetation patterns reflect the rainfall patterns but also reflect the hot dry conditions encountered in the summer months. Hardwood tree areas with grass undergrowth cover extensive areas of the North and South Fork. These are most extensive on the northern- and eastern-exposure slopes. Southern exposure slopes have predominantly grasses and forbes. This is true also for the western-facing slopes of the Ortigalita Ridge on the eastern boundary of the South Fork.

An extensive area of Pinon-Juniper forest exists along the north slopes of Bonanza Peak and the uppermost portion of watershed. The extent of these areas depends upon slope orientation with the northern and eastern slopes showing the greatest growth. The portion of the watershed below the confluence of the North and South Forks is covered solely with short growth grasses and forbes with some areas of salt grass present. Cattle grazing is extensive in the watershed.

No discharges exist that would impact water quality; however, flow into Los Banos Reservoir would greatly change water quality characteristics.

Limited water quality sampling was conducted on Los Banos Creek upstream of Los Banos Reservoir in this study. The United States Geological Survey have collected mineral samples from the Creek in the 1950s prior to construction of Los Banos Reservoir. From combining these two data bases, median salinity and boron concentrations were found to be 550 μmhos/cm and 0.51 mg/L, respectively (Table A-39). Both salinity and boron are low as compared to other study area creeks. As well, the trace element concentrations were found to be low. From the limited data, median selenium and molybdenum concentrations were <1 and <5 μg/L, respectively (Table A-40).

Figure A-19 Distribution of Streamflow Throughout the Year for Los Banos Creek Based Upon a 23-Year Period of Record (Based on DWR Recored for Los Banos Reservoir).



33. SALT CREEK (Merced County)

Salt Creek is a small, low-elevation watershed that covers approximately 21.2 square miles (Figure A-20). Elevation in the watershed is low with a maximum of 1,200 feet above sea level to a minimum of 250 feet near where the creek crosses under Interstate Highway 5.

Topography in the watershed is basically low-elevation rolling hills interspersed with broad valleys. Although elevations reach 1,200 feet above sea level, most of the hills are under 600 feet. Rainfall in the watershed varies from 8-9 inches annually. Due to the low rainfall amounts, the vegetation in the basin is solely short grasses and forbes. Isolated areas of salt grass exist in many of the broad valleys.

There are no discharges in the basin that would impact stream water quality. No trace element water quality sampling has been conducted in the watershed, however, the United States Geological Survey collected one mineral water quality sample in 1952. This sample showed the creek to be very salty with high boron concentrations (Table A-41).

Figure A-20. Location of the Salt Creek Watershed in Merced County.

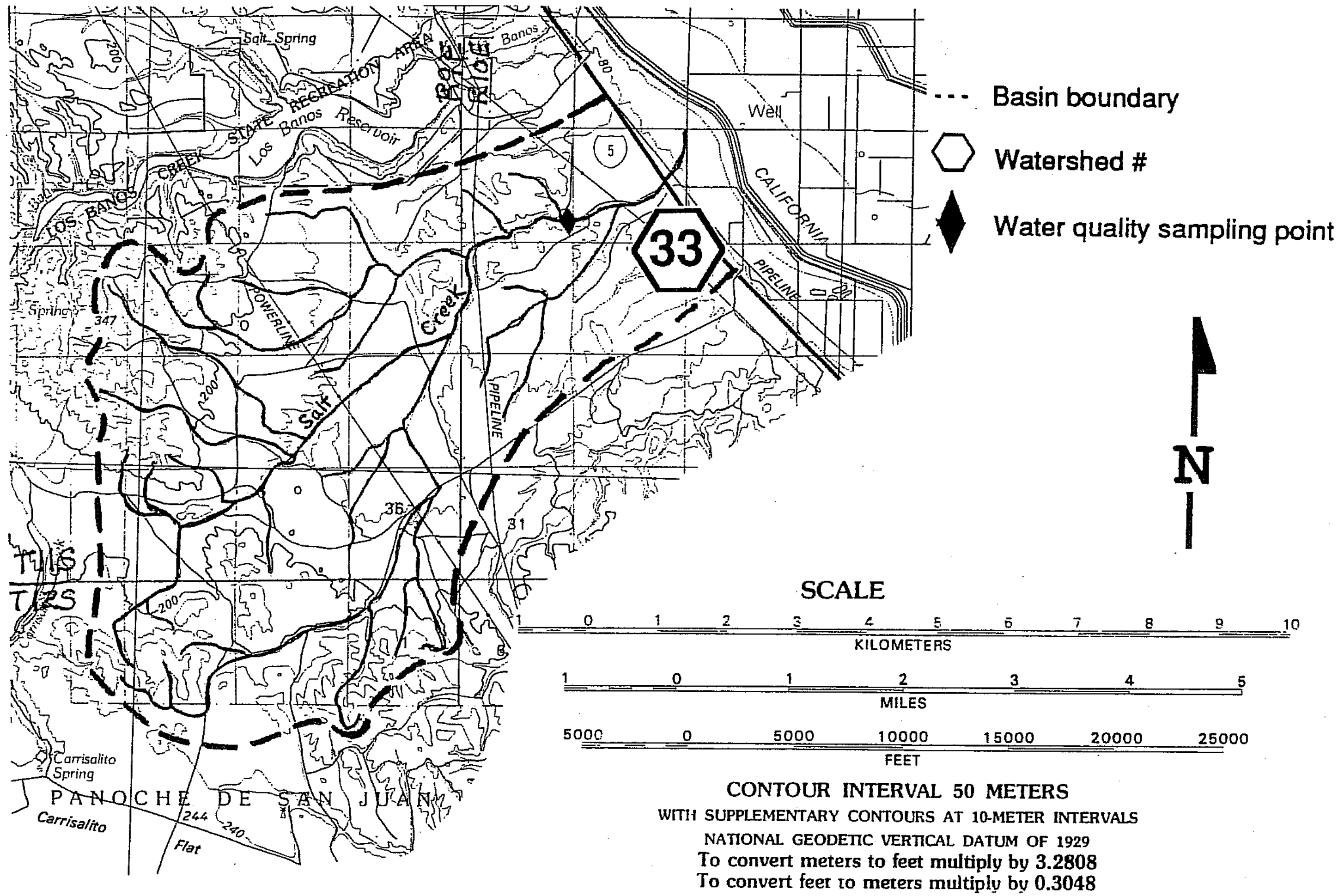
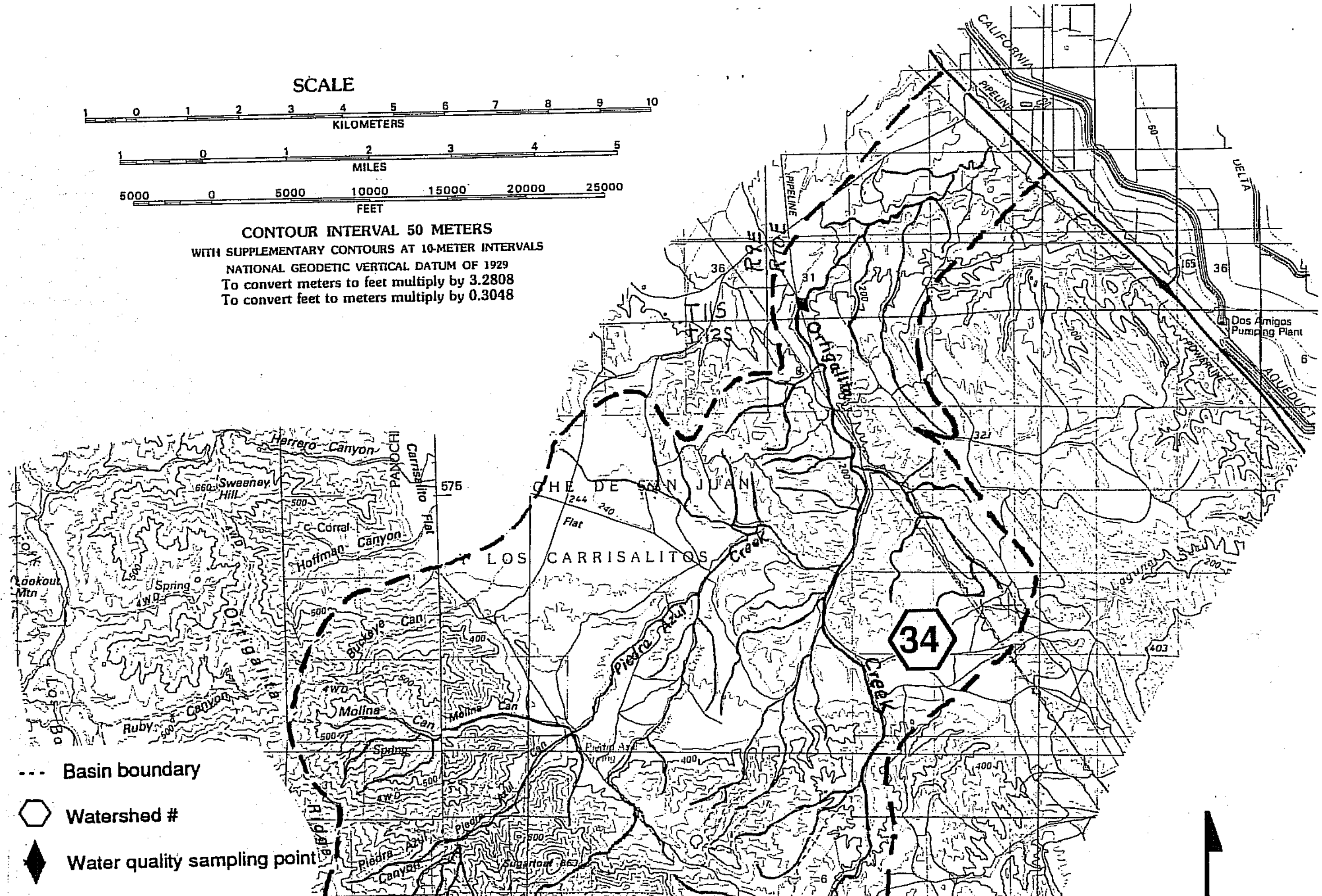


Figure A-21. Location of the Ortigalita Creek Watershed in Merced County.



34. ORTIGALITA CREEK (Merced County)

Ortigalita Creek is a low-elevation watershed that covers 56.3 square miles (Figure A-21). Elevation in the watershed varies from 3,718 feet above sea level near Bonanza Peak to less than 250 where the creek crosses under Interstate Highway 5.

Topography is varied in the watershed. The upper quarter of the watershed is high ridges and peaks. The southern boundary of the upper basin begins at Ortigalita Peak (3,303 MSL) and extends to Bonanza Peak (3,718 MSL) where it turns in a northerly direction along the Ortigalita Ridge (2,500-3,000 MSL). The topography then changes abruptly to a wide flat plateau valley (Carrisalito Flat) at an elevation of 1,000 feet. The watershed then narrows again as Ortigalita Creek moves into a series of low steep hills.

Ortigalita Creek originates at the base of both Ortigalita and Bonanza Peaks, flows through a high plateau valley called Wisenor Flat and then into Carrisalito Flat. Another main tributary, Piedra Azul Creek, drains the north slope of Bonanza Peak and the eastern slope of the Ortigalita Ridge. Piedra Azul Creek then flows into Carrisalito Flat where it joins with Ortigalita Creek.

Rainfall the watershed varies with elevation. Average annual rainfall exceeds 16 inches in the upper watershed but drops to 9 inches in the Carrisalito Flat and falls below 8 inches at the eastern edge of the drainage basin. Higher rainfall amounts are thus concentrated in the western quarter of the basin.

Vegetation closely follows the rainfall amounts but also reflect the long hot dry periods in spring and summer. An extensive pinon-juniper forest exists on the north and east-facing slopes of Bonanza Peak and the eastern slope of Bonanza Peak and the Ortigalita Ridge. These blend into small areas of hardwood trees interspersed in a tall grass area. A pocket of desert shrubs exists in Wisenor Flat, a broad flat valley at the 1,600 foot elevation at the base of Ortigalita Peak. The remaining 75 percent of the watershed is covered with short grasses and forbes with areas of salt grass existing in the plateau areas.

There are no discharges in the basin that would impact water quality. Cattle grazing is extensive in the basin, and a number of windmill-watering points have been established especially in the broad open valleys. Some irrigated agricultural production has come into the basin in its extreme eastern edge.

Water quality sampling was conducted on Ortigalita Creek during this study. In addition, a number of samples were taken on this creek by the United States Bureau of Reclamation during their Westside Drainage study. These combined data bases show median salinity and boron were 5,700 μmhos/cm and 5.7 mg/L, respectively (Table A-42). An extensive data base for trace elements showed median selenium and molybdenum concentrations of 5.0 and <5 μg/L, respectively (Table A-43).

35. UNNAMED CREEKS (Merced County)

This watershed area includes four very small creeks whose total watershed covers 12.9 square miles (Figure A-22). Elevation in this watershed ranges from a maximum near 1,000 feet above sea level to 300 feet where the creeks cross under Interstate Highway 5.

Topography in this area is characterized by steeply sloping hills that fall abruptly to the valley floor. Rainfall is generally less than 8 inches; therefore, the vegetation covering these hills is solely short grass and forbes.

No discharges occur that would affect water quality. No water quality sampling has occurred in this watershed.

36. LAGUNA SECA CREEK (Merced County)

Laguna Seca Creek is a small, low-elevation watershed that covers 7.1 square miles (Figure A-22). Elevations vary from 1,300 feet near Laguna Peak to near 300 feet where the creek crosses under Interstate Highway 5.

Topography in the watershed is characterized by steeply sloping hills that fall abruptly to the valley floor. Rainfall is generally less than 8 inches; therefore, the vegetation covering these hills is solely short grasses and forbes. Cattle grazing is seen throughout the watershed.

No discharges occur that would affect water quality. No water quality sampling has occurred in this watershed.

37. WILDCAT CANYON CREEK (Merced and Fresno Counties)

Wildcat Canyon Creek is one of four small creeks that exit this watershed area to the valley floor. The entire area is a small, low-elevation watershed that covers 32 square miles (Figure A-23). Elevations vary from 1,500 feet to near 300 feet above sea level where the creeks pass under Interstate Highway 5.

Topography, like many of the small watersheds, is characterized by steeply sloping hills that fall abruptly to the valley floor. This watershed also has several higher plateau areas and some irrigated areas on the valley floor prior to under crossing the highway. Average annual rainfall is generally less than 8 inches, but in some years is less than 5 inches. Vegetation covering this watershed is solely short grasses and forbes. Cattle grazing is seen throughout the watershed.

No discharges occur that would affect water quality. No water quality sampling has occurred in this watershed.

Figure A-22. Location of the Laguna Seca Creek Watershed and Several Unnamed Creeks Adjacent to this Watershed in Merced County.

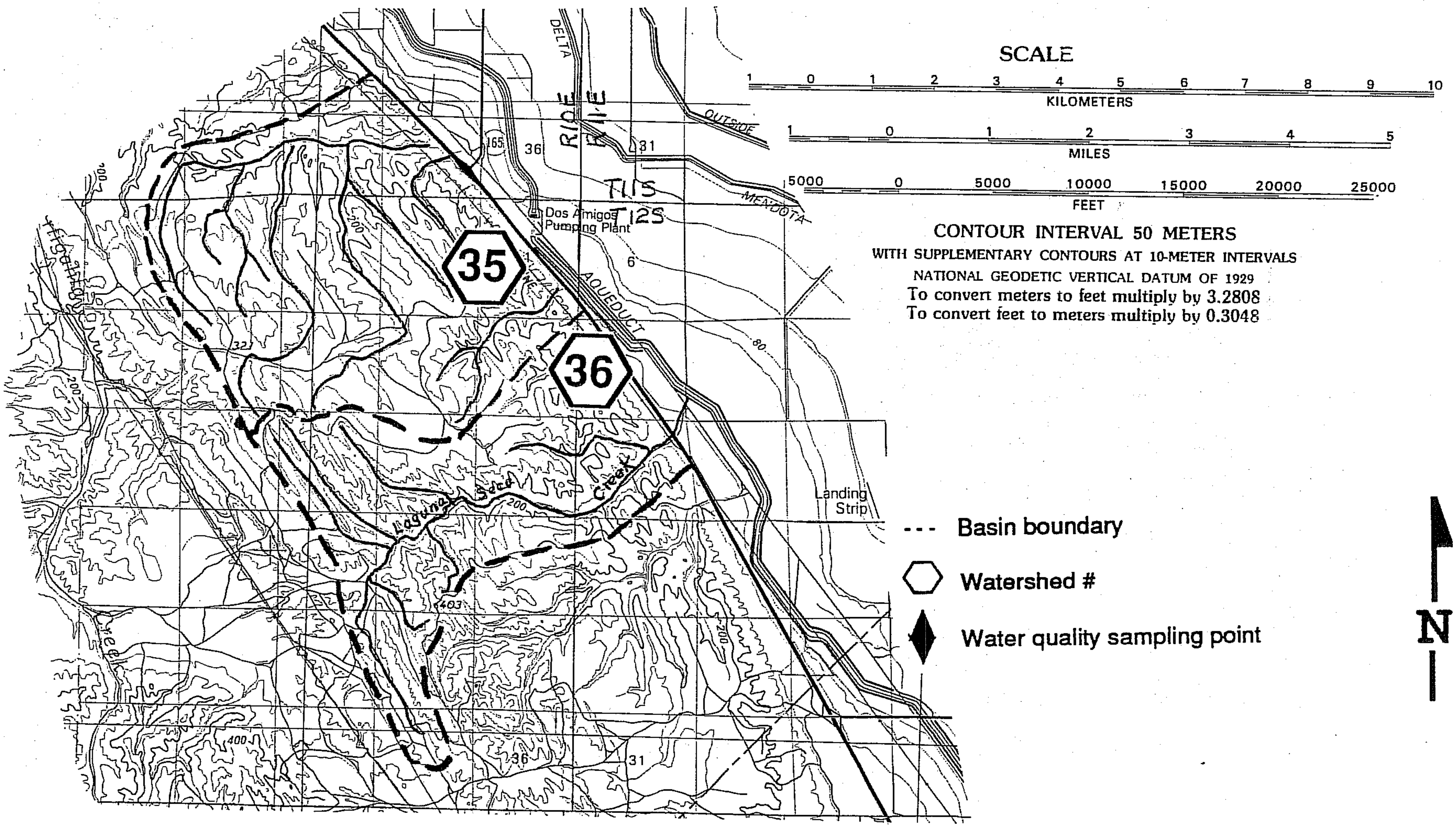
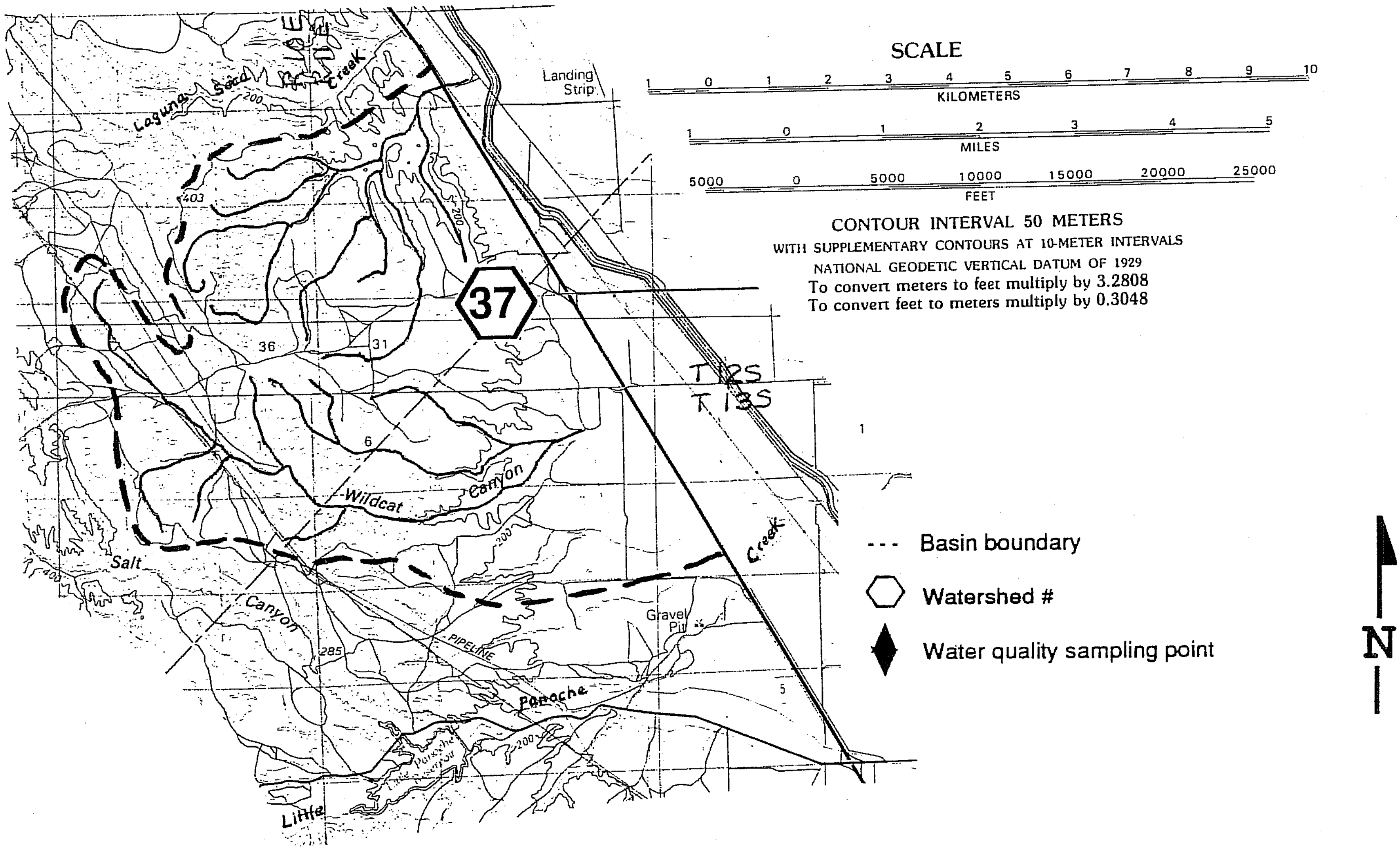


Figure A-23 Location of the Watershed in and Near the Wildcat Canyon Creek Watershed i[n]
Merced and Fresno Counties.



38. LITTLE PANOCHE CREEK (Merced, Fresno and San Benito Counties)

Little Panoche Creek is the third largest watershed in the southern study area. The watershed covers 90 square miles (Figure A-24). Elevations in the watershed range from near 3,700 feet above sea level near Ortigalita Peak to less than 600 feet below the spillway on the Little Panoche Creek Retention Dam.

Little Panoche Creek has several tributaries that reflect the diverse topography in the watershed. The four significant ones are South Fork, Vasquez Creek, Mercy Creek, and Mile Creek. South Fork drains the low-elevation Panoche Hills and the Glaucophane Ridge (1800-2200 MSL), which make up the southeast and the eastern portion of the southern boundaries of the watershed. Vasquez Creek drains the southern slope of Cerro Colorado Peak (3,656 MSL) and the high ridge making up the western portion of the southern watershed boundary. Elevations along this ridge exceed 3,600 feet above sea level including Red Mountain at 3,663 feet. Mercy Creek drains the northern slopes of Cerro Colorado Peak as well as the eastern slope of drainage divide with Los Banos Creek.

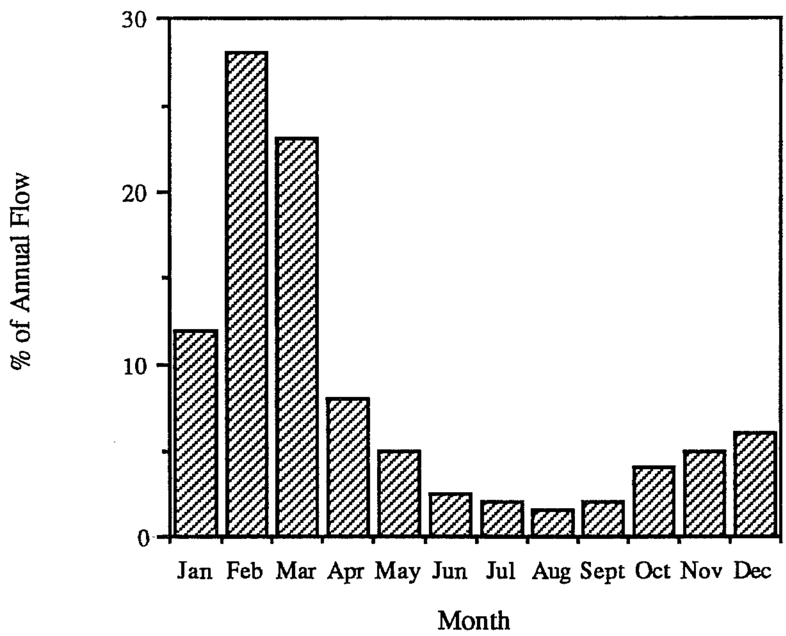
Mine Creek drains the southeastern slopes of Bonanza Peak (3,718 MSL) and the southern slope of Ortigalita Peak (3,303 MSL). All of the flow of these tributaries is supplemented by flow from several springs that are scattered throughout the watershed including hot springs on the South Fork.

All the tributaries come together in the broad Little Panoche Valley. Little Panoche Creek turns east and then flows into the Little Panoche Reservoir. The remainder of the watershed below the confluence of the tributaries is made up of low lying hills. Rainfall in the watershed varies considerably. Average annual rainfall in excess of 15 inches occurs only in isolated areas on the high slopes. Rainfall drops quickly as you move east with the eastern boundary of the basin only receiving 8 inches or less.

The majority of the flow in Little Panoche Creek originates in the higher elevation areas. Some base flow exists due to numerous springs in the watershed. The watershed is greatly different from those further north in that rainfall is significantly less and the watershed begins to take on a more semi-arid appearance.

There is no flow data on the creek; however, a fair set of flow data has been generated by the California Department of Water Resources from the change in storage that has occurred in Little Panoche Retention Reservoir. These calculated flows show the average annual discharge for a 29-year period (1961-present) is 1,435 acre-feet. The annual discharge in this period varied from 9,040 acre-feet in 1983 to 9 acre-feet in 1967 (Table 6). This high degree of variability was coupled by little runoff in normal to dry years and large amounts of runoff in a series of fewer wet years. These extremes of flow put little value in the 16 acre-feet per square mile yield predicted from this flow data. This is less than 20 percent of the yield found in Los Banos Creek (Watershed #32). As with other creeks in the study area, Little Panoche Creek shows heavy flows in the winter rainfall period with flows decreasing throughout the spring and early summer months. In contrast with other streams, however, Little Panoche Creek has a spring-fed base flow that may continue throughout the summer and fall months until the winter rains return. Figure A-25 shows the average percentage of the annual flow for each month for the 29-year period of record. An observation on the data used to complete Figure A-25 is that one heavy year of flow (1983) accounted for almost 50 percent of the total flow in February. Without this year, the distribution may have been different. An addition observation is that this watershed appears to be impacted more by the southern-flow spring rains in February and March than the northern flow storms that predominate in December and January. This characteristic was also observed in Cantua Creek and Los Gatos Creeks further to the south (Table 7).

Figure A-25 Distribution of Streamflow Throughout the Year for Little Panoche Creek Based Upon a 29-Year Period of Record (1961-present), (Based on DWR Records for Little Panoche Creek Reservoir).



Vegetation reflects the rainfall patterns and the long hot-dry summers. The upper portions of the Mine Creek and Mercy Creek drainage basins have pinon-juniper forests, but these are restricted to the north or eastern-facing slopes. Pockets of hardwood tree areas exist, but like pinon-juniper forest areas, they are restricted to the north- and east-facing slopes. Desert shrub vegetation also exists in the basin especially in the South Fork area near both the Panoche Hills and the Glaucophane Ridge. Greater than 70 percent of the basin is covered with low grasses and forbes.

Figure A-24. Location of the Little Panoche Creek Watershed in Fresno, Merced and San Benito Counties.

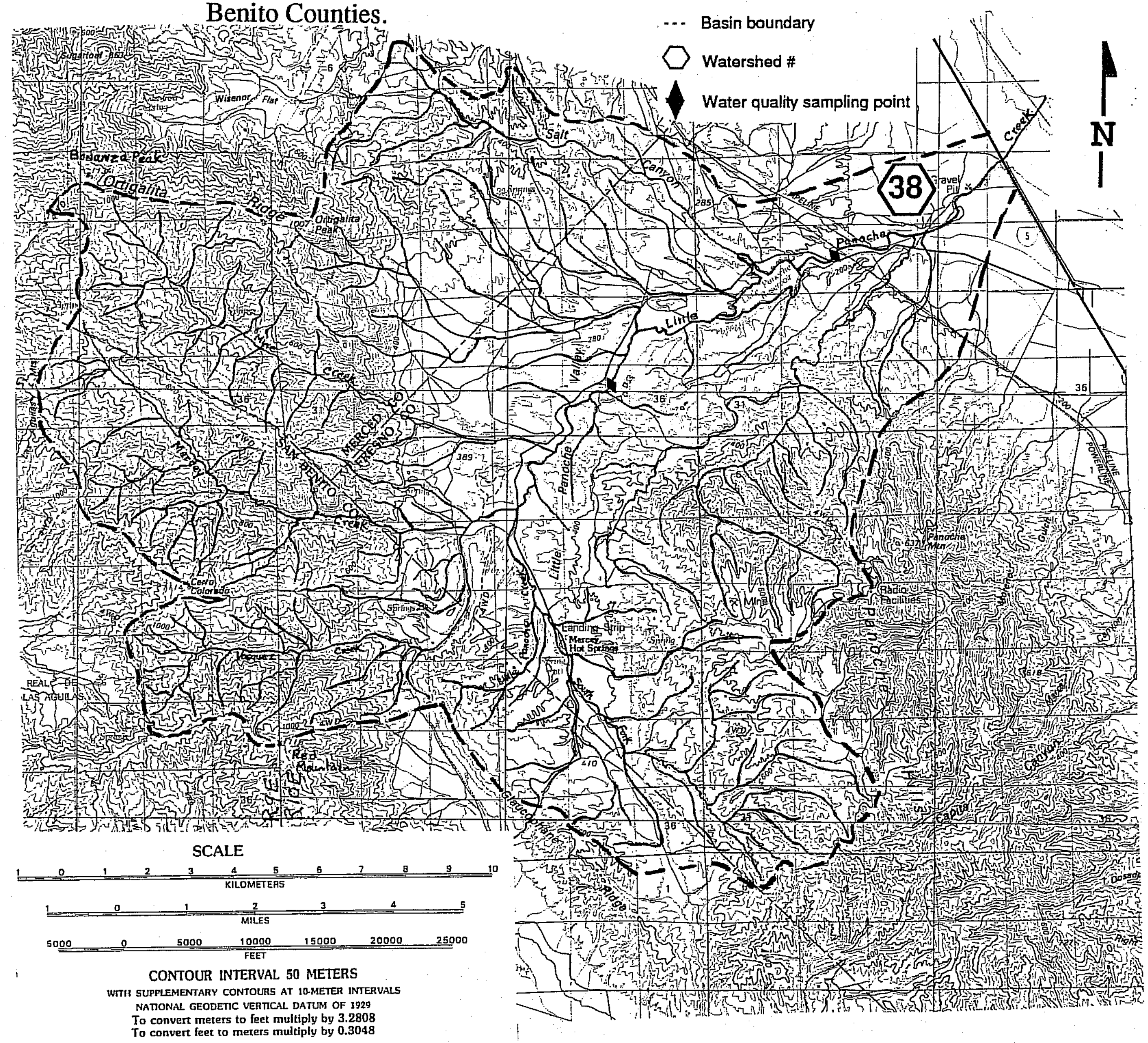
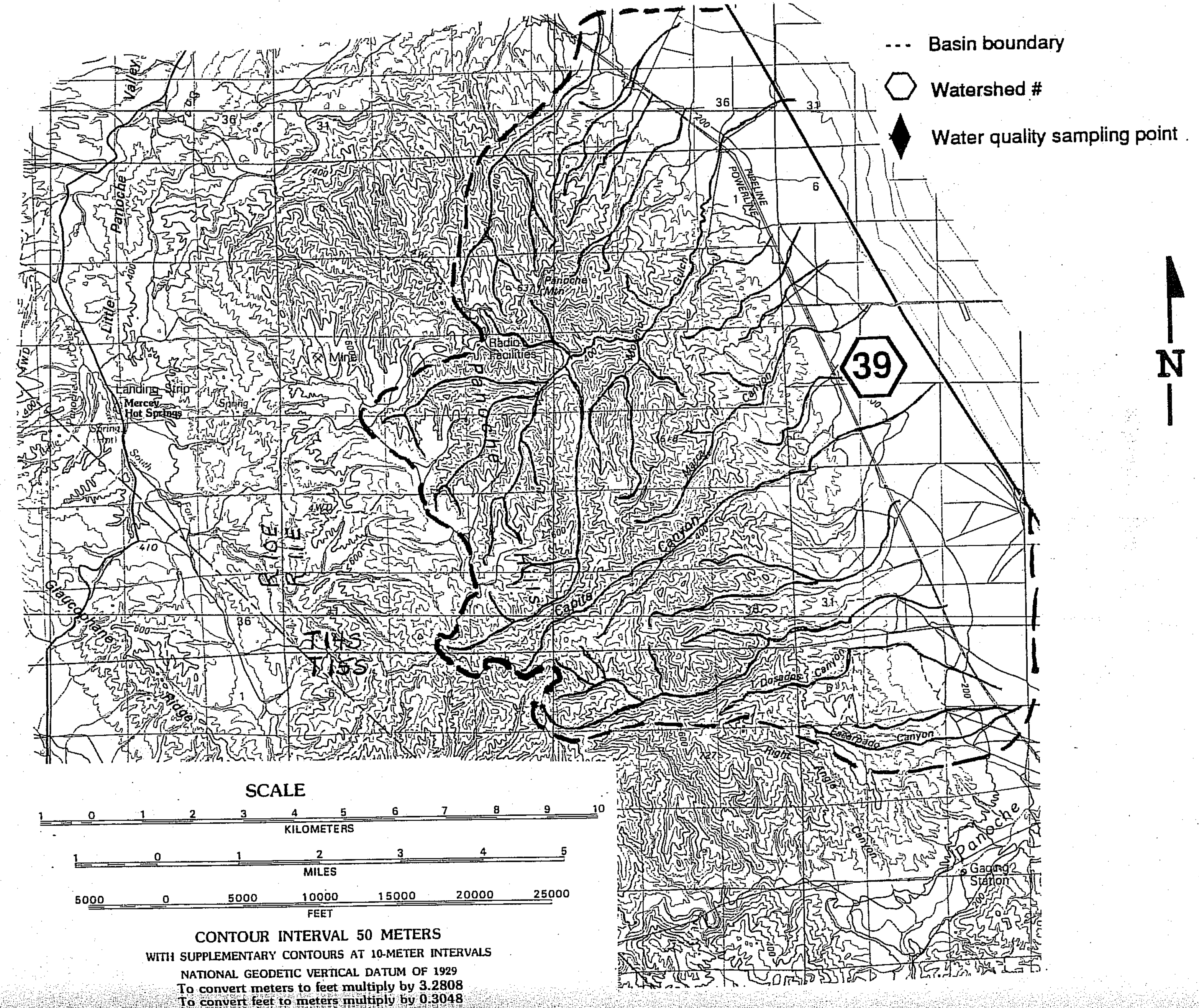


Figure A-26. Location of the Watersheds That Make Up the Moreno Gulch-Panoche Hills Area in Fresno County.



No discharges exist which would impact water quality. Several cattle-watering ponds are present throughout the basin. Flow and water quality in the creek may be strongly influenced by discharges from the springs in the basin.

Water quality sampling was conducted in the Little Panoche Creek watershed both upstream and downstream of the Little Panoche Retention Dam. In addition, the United States Geological Survey and the California Department of Water Resources sampled Little Panoche Creek for mineral water quality. These samples were taken in the 1950s, prior to the Retention Dam; therefore, these samples would represent quality upstream of the Reservoir. The United States Bureau of Reclamation has also conducted sampling for both mineral and trace element water quality downstream of the Retention Dam.

The combined data bases of the sampling organizations showed the median salinity and boron concentrations above Little Panoche Reservoir as 1,700 μmhos/cm and 6.4 mg/L, respectively (Table A-44). The median values below the Reservoir are 3,300 μmhos/cm for salinity and 13 mg/L for boron (Table A-45). The median values below the Reservoir are twice those above the reservoir showing the potential impact of the Reservoir.

The combined data bases for trace elements showed a very low median selenium concentration of 0.5 μg/L or less for both above and below the Reservoir. Median molybdenum concentrations were also low at <5μg/L (Tables A-46 and A-47).

39. MORENO GULCH-PANOCHE HILLS (Fresno County)

The Moreno Gulch-Panoche Hills watershed consists of a dozen or more small watersheds that drain the low-elevation hills known as the Panoche Hills. The entire area covers 70 square miles (Figure A-26). Elevation ranges from 2,090 feet at Panoche Mountain to less than 600 feet above sea level where these creeks pass under Interstate Highway 5.

Topography is steep hills that dip abruptly to the valley floor. The average annual rainfall in these low-elevation hills is less than 8 inches. Vegetation reflects the low rainfall and hot summers. The entire area is covered with sparse low grasses and forbes.

No discharges occur in this area. No water quality sampling has been conducted on these creeks.

40. PANOCHE CREEK (Fresno and San Benito Counties)

Panoche Creek is the largest watershed in the southern study group. The Panoche Creek watershed encompasses both the Panoche Creek drainage and the Silver Creek drainage basins. The Panoche-Silver Creek drainage covers approximately 275 square miles (Figure A-27). Elevation in the basin ranges from greater than 5,000 feet above sea level near San Benito Mountain to less than 600 feet where Panoche Creek flows into the valley floor.

Topography varies throughout the basin and differs greatly between the Panoche and Silver Creek drainages. The Silver Creek drainage is the smaller of the two and drains areas with high peaks. Silver Creek has three main tributaries: San Carlos Creek, Los Pinos Creek and Larious Creek. Los Pinos Creek drains the western portion of the watershed. Flow originates along the northern slopes of Bucks Peak (4,164 MSL) along the southern boundary; however, the majority of Los Pinos Creek watershed is in lower hills and a wide flat valley. This flat valley (2,000 MSL) forms a drainage divide with Panoche Creek. Several minor tributaries inflow to Los Pinos Creek from the Griswold Hills, a series of low rolling hills that contain several oil fields. Los Pinos Creek is joined by Larious Creek from the south. Larious Creek drains a high ridge which makes up the southern boundary of the watershed. This ridge extends from Tucker Mountain (4,090 MSL) to the western slopes of Idria and Sampson Peak, which exceed 4,000 feet above sea level. The two creeks flow east and are joined by San Carlos Creek flowing from the south. San Carlos Creek drains the north slopes of San Carlos Peak (4,845 MSL) and San Benito Mountain (5,248 MSL). They are two of the highest peaks of the San Joaquin Ridge that makes up a significant portion of the southern boundary of Silver Creek.

San Carlos Creek joins Larious Creek near an elevation of 2,000 feet above sea level and continue as Silver Creek as it flows through a narrow canyon between the Griswold Hills to the west and the Tumey Hills to the east. These hills are low elevation steeply sloping hills that contribute little flow to Silver Creek. Silver Creek joins Panoche Creek near the 600 foot elevation.

Panoche Creek originates near the Panoche Pass (2,200 MSL) along the western boundary of the drainage basin. It flows in a west to east direction through a wide agricultural valley (Panoche Valley) at an elevation of 1,300 feet above sea level. After leaving the Panoche Valley, the creek enters a narrow canyon in the Panoche Hills, where it flows east to converge with Silver Creek flowing from the south.

Panoche Creek has three main tributaries from the south and one from the north that join it as it flows through the Panoche Valley. Las Aguilas Creek joins from the north as it drains the southern slopes of Red Mountain (3,663 MSL) and the lower hills of the Glaucophane Ridge, which forms the drainage divide with Little Panoche Creek.

The most significant flows come from the tributaries entering from the south. The western most is Bitterwater Canyon Creek which joins Panoche Creek upstream of the Panoche Valley near Llanada. This creek drains the extensive high ridge area south of the Panoche Pass and along the southwestern boundary of the basin. This ridge extends from the 2,200 foot elevation at the Panoche Pass south to Big Mountain (3,992 MSL). The ridge continues in a southeastern direction at elevations in excess of 3,500 feet. The ridge continues past Smoker Mountain (3,828 MSL) at elevations in excess of 3,800 feet.

The second tributary, Clough Canyon Creek, is a small drainage basin that drains the northern slopes of Meyers Peak (3,721 MSL) and Buck Peak (3,534 MSL), two high peaks in the immediate vicinity of the Panoche Valley. Clough Canyon Creek joins Panoche Creek near the town of Panoche.

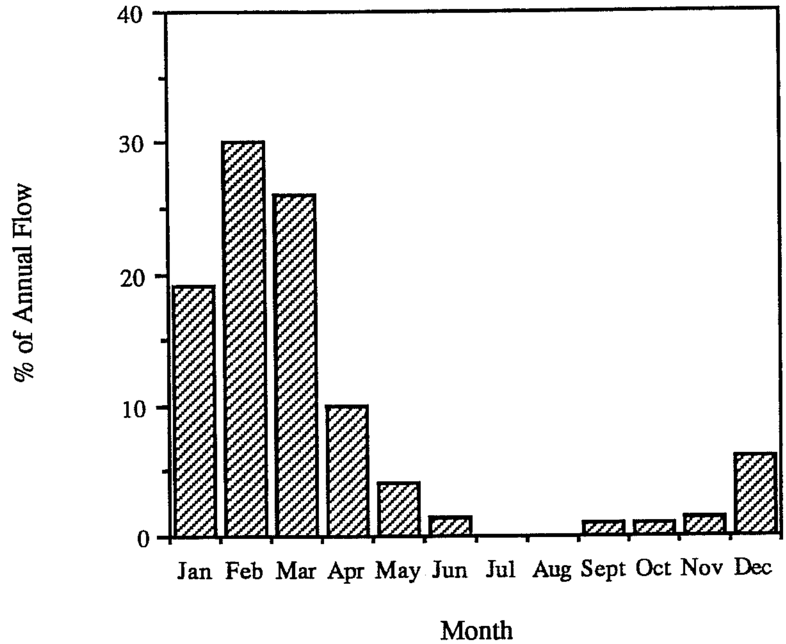
The largest tributary is Griswold Creek. It is formed by the confluence of two smaller tributaries. The Pimental Creek branch drains the southern slopes of Meyers Peak and Buck Peak as well as the northern slopes of the ridge that have elevations in excess of 3,500 feet. The Vallecitos Creek branch drains the northern slopes of Bucks Peak (4,164 MSL) as well as the Vallecitos Valley (2,000 MSL) area. These branches join at the northern end of Vallecitos Valley and flow through the low-elevation Griswold Hills to join Panoche Creek at the lower end of the Panoche Valley. Only insignificant inflows occur below this point prior to the confluence of Panoche and Silver Creek.

Average annual rainfall in the watershed varies from near 22 inches along the higher elevation ridges near the Panoche Pass but decrease rapidly as you move east and south. The higher elevation areas of Silver Creek only receive 16-18 inches per year while rainfall in the lower basin is less than 8 inches per year.

Limited stream flow gauging has taken place on Panoche or Silver Creek. One measurement point was operated from 1949-1970 at a point immediately downstream of the Panoche-Silver Creek confluence. This limited data base shows that the basin experiences extremes of flow and the little information on flow characteristics can be developed from this data. Excellent flow records do exist, however, for Cantua Creek and Los Gatos Creeks immediately to the south of the Panoche-Silver Creek Drainage Basin. Good discharge records are available for Los Gatos Creek since 1945 and for Cantua Creek since 1967 (Table 6). The average annual discharge for the 45-year period of record for Los Gatos Creek is 4,050 acre-feet while for the 23-year period of record for Cantua Creek is 2,340 acre-feet.

As with other creeks in the study area, the annual discharge varied from 35,080 acre-feet in 1983 to zero flow in 1989 for Los Gatos Creek and from 13,639 acre-feet in 1983 to 2.5 acre-feet in 1989 for Cantua Creek. The average annual flow translates into an average yield per square mile approximately 42 acre-feet for Los Gatos Creek and 50 acre-feet for Cantua Creek. This is in contrast to the 9 acre-feet per square mile yield estimated from the limited data base on Panoche-Silver Creek. The average yield for Los Gatos and Cantua Creeks is only one quarter of that found for Marsh Creek in the northern study area (Watershed #4) and one-half of that found for Del Puerto Creek (Watershed #19), Orestimba Creek (Watershed #26) and Los Banos Creek (Watershed #32). The low yield found in the Panoche-Silver Creek watershed is likely the result of a poor data base but also may be associated with the large size of the Panoche-Silver Creek Drainage Basin in comparison to the percentage of the basin that contains higher water-yielding, high-elevation areas and the significantly lower rainfall in the drainage basin as compared to those in the middle and northern study areas.

Figure A-28 Average Distribution of Streamflow Throughout the Year for Three Creeks (Los Gatos, Cantua and Panoche-Silver) Based Upon Their Periods of Record.



As with other creeks in the study area, all three, Los Gatos, Cantua, and Panoche-Silver Creek have heavy flows in the winter rainfall period with flows decreasing throughout the spring and early summer months. Figure A-28 shows the average of the three creeks (Los Gatos, Cantua and Panoche-Silver) in percentage of annual flow that occurs in each month.

Vegetation is sharply curtailed by elevation. Only the north and eastern slopes of the highest elevation ridges (>2,500 feet) support chaparral and mountain bush. Scattered hardwood tree areas occur on other north- and eastern-facing slopes in the same elevation zone. An extensive area of pinon-juniper forest occurs in the San Carlos-San Benito Mountain area due largely to the high altitudes. The remainder of the basin is composed of low grasses and forbes, but many areas of the lower basin show sparse vegetation or desert-like conditions. Desert vegetation exists in extensive areas including most of the Griswold Hills.

The basin has several activities that could impact water quality, but no discharges occur on a continuous basis. Silver Creek is impacted by three activities, the Vallecitos Oil Fields, New Idria Mining area and excessive grazing in the basin. The Vallecitos Oil Field produces brine water with its oil field production. This is evaporated in a series of ponds. Discharges continue to occur from the abandoned mine area near New Idria. New Idria mine was once the largest mercury mine in the United States. This discharge affects water quality in San Carlos Creek. Excessive grazing in the watershed has stripped vegetation from many slopes especially in the lower rainfall areas. This has increased erosion; and sediment in the creek, as well as several saline-seep areas have developed.

Panoche Creek is also subject to impacts from excessive grazing, the Vallecitos Oil Field activities and irrigated and dryland agriculture. Limited mining also occurs in the area with little or no known impact. The oil field and grazing impacts are the same as those in Silver Creek. The Panoche Valley is used for both dryland and irrigated agriculture, which also produces sediment during periods of high runoff. An additional problem on both watersheds is the loss of riparian vegetation which causes unstable stream bank and channel erosion.

Water quality sampling was conducted in the Panoche-Silver Creek Drainage Basin. Two sampling sites were used, one on Silver Creek above its inflow to Panoche Creek and one on Panoche Creek downstream of the Silver Creek inflow. In addition, the United States Bureau of Reclamation and California Department of Water Resources have collected various samples at both these locations. From the combined data bases, median salinity was 9,250 μmhos/cm and 7,650 μmhos/cm for Panoche-Silver Creek and Silver Creek, respectively (Tables A-48 and A-49). The median boron concentration for Panoche-Silver Creek was 12 mg/L, and for Silver Creek, it was 11 mg/L. Mineral water quality data for Cantua and Los Gatos Creeks were not collected as part of this study; however, the data bases established by other agencies are presented in Table A-50 for Cantua Creek and Table A-51 for Los Gatos Creek.

Trace element water quality samples were also collected as part of this study. The limited data base developed shows median selenium concentrations of 3 μg/L for Panoche-Silver Creek and 7.5 μg/L for Silver Creek (Table A-52 and A-53). The median molybdenum concentrations were 8 and 9.6 μg/L for Panoche-Silver and Silver Creek, respectively.

Table A-1. Mineral Water Quality Data for Sand Creek, Contra Costa County.

Sampling Location: Latitude 37° 56' 49", Longitude 121° 46' 24"
NE 1/4, NW 1/4, SE 1/4, Sec. 8, T.1N., R.2E.,
at Deer Valley Rd.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS
						mg/L Total Recoverable											
4/18/84	1600				3750	8.7		2950	240	156	627	13	0				
5/31/84	905		68		3800	3.7	250	1500	262	182	360	11.3	0	294	294		
2/14/86	720	1.0		6.0	1600	2.8	150	470	152	58	178	8.4	0	76	76	440	1100
2/24/86	1120	1.0		8.1	2600	4.1	250	840	192	84	295	7.5	8	220	228	890	2000
3/17/86	1240	4.0		8.0	1400	1.6	92	590	135	52	157	7.2	0	180	180	520	1100
4/2/86	845	0.8		7.4	3000	5.0	250	1000	192	107	332	7.4	0	180	180	1040	2200
4/24/86	815	1.5		6.6	3500	6.2	220	1500		110	430	12.0	0	100	100	1060	2800
Minimum					1400	1.6	92	470	135	52	157	7.2	0	76	76	440	1100
Median					3000	4.1	235	1000	192	107	332	8.4	0	180	180	890	2000
Maximum					3800	8.7	250	2950	262	182	627	13	8	294	294	1060	2800
# Data					7	7	6	7	6	7	7	7	7	6	6	5	5

Table A-2 Total Recoverable Trace Element Water Quality Data for Sand Creek, Contra Costa County.

Sampling Location: Latitude 37° 56' 49", Longitude 121° 46' 24"
NE 1/4, NW 1/4, SE 1/4, Sec. 8, T.1N., R.2E., at Deer Valley Rd.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb
		µg/L Total Recoverable					
2/14/86	720	2.0	9	2	3	17	<5
2/24/86	1120	7.0	9	3	6	27	<5
3/17/86*	1240	3.0	11	14	39	85	<5
4/2/86	845	4.0	6	7	1	38	<5
4/24/86	815	3.9	10	6	3	17	<5
Minimum		2.0	6	2	1	17	<5
Median		3.9	9	6	3	27	<5
Maximum		7.0	11	14	39	85	<5
# Data		5	5	5	5	5	5

* Very turbid water.

Table A-3. Mineral Water Quality Data for Deer Creek, Contra Costa County.

Sampling Location: Latitude 37° 55' 17", Longitude 121° 46' 39"
NE 1/4, SE 1/4, NW 1/4, Sec. 20, T.1N., R.2E.,
Deer Creek at Deer Valley Road, 2.1 mi S of
Lone Tree Way and 1/2 mi N of Chadbourne Road.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS
						mg/L Total Recoverable											
2/22/84					2600	0.62	290										
5/31/84	915		68		5300	1.3	280	2700	445	305	630	11.7		410			
2/14/86	735	2.0		7.1	3700	1.1	360	1400	148	197	532	7.4	0	170	170	1100	3000
2/24/86	1130	0.6		8.0	4200	0.78	380	2200	323	178	535	7.5	0	310	310	1500	3600
3/17/86	1215	1.5		8.2	1800	0.4	130	750	137	77	214	4.9	0	160	160	620	1400
4/2/86	900	0.5		7.6	4300	1.0	370	2400	355	197	524	3.2	0	300	300	1840	3800
10/23/86	930			6.7	5000	1.1	350	2600	490	290	420	4.0	0	390	390	2300	5000
11/19/86	800			7.0	4900	1.0	280	2500	430	250	370	3.6	0	410	410	2300	2800
12/16/86	900			7.6	7100	1.2	420	3700	560	480	680	5.8	0	210	210	2800	6400
1/14/87	830			7.1	6200		360	2500	440	340	770	3.7				2700	
3/17/87	930			7.4	7650	1.4	120										
4/15/87	845			7.2	7750	1.7	610										
Minimum					1800	0.4	120	750	137	77	214	3.2	0	160	160	620	1400
Median					4950	1.1	370	2500	430	250	532	4.5	0	305	300	2070	3600
Maximum					7750	1.7	610	3700	560	480	770	7.5	0	410	410	2800	6400
# Data					12	11	12	9	9	9	9	8	7	8	7	8	7

Table A-4 Total Recoverable Trace Element Water Quality Data for Deer Creek, Contra Costa County.

Sampling Location: Latitude 37° 55' 17", Longitude 121° 46' 39"
NE 1/4, SE 1/4, NW 1/4, Sec. 20, T.1N., R.2E.,
Deer Creek at Deer Valley Road, 2.1 mi S of
Lone Tree Way and 1/2 mi N of Chadbourne Road.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
2/14/86	735	2.0	27	14	18	57	<5		
2/24/86	1130	12	14	5	6	23	<5		
3/17/86	1215	4.0	8	4	8	11	<5		
4/2/86	900	13	8	11	2	10	<5		
10/23/86	930	0.4	0	<1	<1	<5	<5	3	
11/19/86	800	1.8	<5	<1	<1	<5	<5	16	
12/16/86	900	2.6	<5	<1	<1	<5	<5	1	
1/14/87	830	12	<5	4	2	<5	<5	4	
3/17/87	930	5.3	1.5		<0.5	5	<1	6	42
4/15/87	845	1.7							
Minimum		0.4	0	<1	<0.5	<5	<1	1	
Median		3.3	3	4	2	5	<5	4	
Maximum		13	27	14	18	57	<5	16	
# Data		10	9	8	9	9	9	5	

Table A-5. Mineral Water Quality Data for Marsh Creek, Contra Costa County.

Sampling Location: Latitude 37 52' 23", Longitude 121 43' 34"
NW 1/4, NE 1/4, SW 1/4, Sec. 2, T.1S., R.2E.,
Marsh Creek Rd, 1.75 mi W of Vasco Rd and
Camino Diablo Rd junction.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
					mg/L Total Recoverable												
9/27/46				1460	3.7	170	197	56	54	156							DWR
2/1/52	1330		8.0	643	1.1	33	123	51	31	39	1.4	0	155	155	254	390	DWR
2/5/52			7.4	618	1.0	31	117	54	26	36	1.6	0	149	149	242	370	DWR
4/28/52	1330		8.0	785	1.6	50	120	61	39	59	2.0	0	254	254	312	500	DWR
4/18/84	1520			900	2.3		306	66	45	106	1.6						RB
5/31/84	1300			1200	3.2	130	280	43	51	152	3.8		310				RB
12/17/85	820	1.5	8.0	1750	4.3	240	240	114	80	163	4.0		300	300		1160	RB
1/16/86	1215	3.0	8.3	1400	4.8	200	270					0	200	200			RB
2/14/86	750	15	8.1	650	1.6	65	150	112	27	53	2.5	0	180	180	230	420	RB
2/24/86	1205	*	8.1	660	1.3	40	100	50	22	48	2.6	0	190	190	240	380	RB
3/14/86	1150	*	8.2	500	0.6	30	80	46	24	40	2.0	0	180	180	220	360	RB
4/2/86	915		8.1	980	1.6	62	140	65	42	81	2.7	12	260	272	360	590	RB
4/24/86	1015	14.0	8.6	920	2.3	85	180		47	99	3.0	16	200	216	300	570	RB
5/13/86	1000	8.0	8.6	1000	2.7	91	190	33	43	140	2.2	8	230	238	230	610	RB
6/11/86	745	2.5	7.3	1200	3.2	110	200	30	45	130	4.4	0	250	250	340	780	RB
10/23/86	1010	2.0	7.8	1600	3.8	230	250	66	65	160	3.2	0	340	340	500	1000	RB
11/19/86	830	2.0	7.5	1600	3.5	170	190	60	62	120	2.8	0	350	350	460	930	RB
12/16/86	930	1.0	8.0	1800	3.9	190	290	57	73	170	3.4	0	340	340	520	1100	RB
1/14/87	900	3.5	7.6	1700		140	230	98	76	200	2.6				480		RB
2/19/87	930	3.5	7.4	1400	3.8	120	140					0					RB
3/17/87	1000	7.0	8.2	1000	2.6	120											RB
4/15/87	910	1.5	8.1	1400	4.0	120											RB
1/14/88	940		7.8	1450	4.6	160	250										RB
Minimum				500	0.6	30	80	30	22	40	1.4	0	149	149	220	360	
Median				1200	3.0	120	190	57	45	115	2.6	0	240	238	305	580	
Maximum				1800	4.8	240	306	114	80	200	4.4	16	350	350	520	1160	
# Data				23	22	22	21	17	18	18	17	15	16	15	14	14	

* Very high flow due to heavy rainfall (flooding).

Table A-6 Total Recoverable Trace Element Water Quality Data for Marsh Creek, Contra Costa County.

Sampling Location: Latitude 37° 52' 23", Longitude 121° 43' 34"
NW 1/4, NE 1/4, SW 1/4, Sec. 2, T.1S., R.2E.,
Marsh Creek Rd, 1.75 mi W of Vasco Rd and
Camino Diablo Rd junction.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		μg/L Total Recoverable							
12/17/85	820	1.0	6	<1	<1	7	<5	12	
1/16/86	1215	1.0	<5	<1	2	3	<5		
2/14/86	750	0.4	<5	5	5	76	<5		
2/24/86	1205	1.0	<5	6	18	23	<5		
3/14/86	1150	1.0	<5	7	17	62	<5		
4/2/86	915	<1	<5	2	8	36	<5		
4/24/86	1015	3.3	<5	4	<1	6	<5		
5/13/86	1000	1.0	<5	1	<1	<5	<5		
6/11/86	745	1.4							
10/23/86	1010	1.0	1.0	<1	<1	<5	<5	<5	
11/19/86	830	0.8	<5	<1	<1	<5	<5	<1	
12/16/86	930	1.0	<5	<1	<1	<5	<5	<1	
1/14/87	900	1.0	<5	1	2	5	<5	1	
2/19/87	930	1.2							
3/17/87	1000	0.7	1.1	1	<.5	28	<1	5	<1
4/15/87	910	0.9							
1/14/88	940	1.5							
Minimum		<1	<5	<1	<1	<5	<5	<1	
Median		1.0	<5	1	1	6	<5	<5	
Maximum		3.3	6	7	18	76	<5	12	
# Data		17	12	12	12	12	12	5	

Table A-7. Mineral Water Quality Data for Kellogg Creek, Contra Costa and Alameda Counties.

Sampling Location: Latitude 37° 51'13", Longitude 121° 41'43"
SW 1/4, SW 1/4, SW 1/4, Sec. 7, T.1S., R.3E.,
1.5 mi S of Vasco Road and Camino Diablo Road juntion.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
4/29/80	1250		68	8.3	1300													DWR
12/4/80	1515	0.3	54	8.1	2000	6.5	335	209	54	50	302	4.8	0	339	339	340	1180	DWR
1/23/81	1050	0.8	54	8.3	1800	8.0	311	177	61	48	292	2.0	0	369	369	350	1180	DWR
1/27/81	1945	7.0	50	8.2	1050	4.5	195	102	52	31	160	4.6	0	222	222	257	745	DWR
3/19/81	1200	0.7	56	8.3	1650	7.6	285	159	56	44	250	2.6	0	307	307	321	1100	DWR
5/7/81	1500		74	8.2	2000	9.1	380		24	53			0	336	336	278		DWR
11/13/81	1110	0.4	62	7.7	2130	7.4	380	178	47	51	344	4.7	0	368	368	327	1290	DWR
11/17/81	1050	0.2	63	7.9	2150	7.6	389		59	46			0	295	295	336		DWR
12/21/81	1100	2.0	54	8.1	480	1.3	50	43	26	13	51	3.3			116	119	306	DWR
1/6/82	1340	53	45	7.8	625	1.2	68	56	35	18	59	2.1			143	162	390	DWR
1/28/82	1245	51	54	8.1	750	1.9			55	25	81	2.9				240		DWR
2/15/82	1400	130	59	7.7	220	0.7	14	9	17	7	21	2.5			76	72	155	DWR
3/31/82	740	380	51	7.6	170	0.5	11	7	16	6	19	3.0			64	53	115	DWR
4/18/84	1430				1100	3.0		219	56	63	160	0.3						RB
5/31/84	1320		80		2100	6.3	360	260	39	58	400	4.0	0	401	401			RB
11/19/85	1250			8.0	2200	7.6	330		67	58	322		0	410	410		1290	RB
12/17/85	845			8.6	2300	8.4	360	210										RB
1/16/86	1230	0.5		8.3	2500	9.2	400	280					16	360	376			RB
2/14/86	805	2.0		8.1	1300	4.8	240	200	44	29	184	4.7	0	160	160	230	830	RB
2/24/86	1230	23		8.1	810	1.5	90	100	58	27	86	3.0	16	220	236	260	530	RB
3/17/86	1130	*		8.1	600	1.1	56	68	49	22	61	2.3	0	200	200	220	410	RB
4/2/86	930	5.0		8.0	1000	2.3	97	110	63	36	115	2.4	0	300	300	320	610	RB
4/24/86	1030	5.0		8.7	1200	3.0	120	140		39	140	2.4	0	280	280	270	700	RB
5/13/86	1040	3.0		8.6	1200	4.0	140	120	24	39	170	1.7	16	220	236	210	640	RB
6/11/86	810	1.5		8.0	1500	4.9	210	170	24	43	240	2.6	16	290	290	280	910	RB
7/15/86	840	3.0		7.7	1900	6.7	290	180	28	52	300	3.2	0	400	400	280	1100	RB
8/14/86	830	2.0		8.3	2100	7.7	320	180	28	51	360	1.6	0	370	370	280	1200	RB
9/15/86	830	2.0		8.0	2500	8.2	340	210	55	62	380	3.9	0	440	440	310	1400	RB

Table A-7 (continued). Mineral Water Quality Data for Kellogg Creek, Contra Costa and Alameda Counties.

Sampling Location: Latitude 37° 51'13", Longitude 121° 41'43"
SW 1/4, SW 1/4, SW 1/4, Sec. 7, T.1S., R.3E.,
1.5 mi S of Vasco Road and Camino Diablo Road juntion.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
10/23/86	1035	3.0		8.0	1900	6.3	340	180	43	52	280	2.1	16	390	406	300	1100	RB
11/19/86	900	3.5		7.8	1800	6.0	220	150	42	50	220	1.8	0	410	410	320	1000	RB
12/16/86	1000	4.0		8.2	2100	7.0	290	220	46	58	260	2.8	0	400	400	360	1300	RB
1/14/87	920	3.0		8.1	1900		190	120	71	55	320	2.0				340		RB
2/19/87	950	3.5		7.2	1450	4.5	190	110					0					RB
3/17/87	1015	5.0		8.1	1350	3.8	190											RB
4/15/87	930	2.0		8.5	1850	6.9	270											RB
5/13/87	930			8.3	2250	7.5	390											RB
11/19/87	750	1.5			2300	7.2	330	200					0	460	460			RB
12/15/87	915	1.5		8.4	2250	6.8	320	200										RB
1/14/88	1010			8.2	2250	6.8	290	200										RB
3/23/88	1000			8.6	2150	6.8	310	180					52	350	402			RB
3/16/89				8.1	1900		200	140	69	37	210		0	380	380	330	930	CCCWD
3/31/89					1500		180	140	79	38	210		0	400	400	350	920	CCCWD
7/1/89				8.1	1500		210	92	55	38	230		0	390	390	290	940	CCCWD
10/30/89				8.1	2300		450	120	100	38	380		0	440	440	410	1300	CCCWD
11/29/89				8.0	2200		490	150	79	38	320		0	420	420	350	1200	CCCWD
1/16/90				8.0	1600		220	110	70	35	230		0	370	370	320	950	CCCWD
3/28/90				8.0	1500		200	110	75	38	210		0	410	410	340		CCCWD
Minimum					170	0.5	11	7	16	6	19	0.3	0	160	64	53	115	
Median					1800	6.4	290	165	54	39	225	2.6	0	370	370	300	940	
Maximum					2500	9.2	490	280	100	63	400	4.8	52	460	460	410	1400	
# Data					47	38	44	40	35	36	34	26	33	32	36	33	29	

* Very high flow due to heavy rainfall (flooding).

Taable A-8 Total Recoverable Trace Element Water Quality Data For Kellogg Creek, Contra Costa and Alameda Counties.

Sampling Location: Latitude 37° 51'13", Longitude 121° 41'43"
SW 1/4, SW 1/4, SW 1/4, Sec. 7, T.1S., R.3E.,
1.5 mi S of Vasco Road and Camino Diablo Road juntion.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
11/19/85	805	4.0	<5	4	3	<5	<5	2	
12/17/85	845	6.0	<5	<1	1	<5	<5		
1/16/86	1230	7.0	<5	2	4	<5	<5		
2/14/86	805	3.0	8	11	13	56	<5		
2/24/86	1230	3.0	<5	1	5	<5	<5		
3/17/86	1130	2.0	5	4	9	6	<5		
4/2/86	930	3.0	<5	<1	<1	<5	<5		
4/24/86	1030	3.5	<5	<1	<1	<5	<5		
5/13/86	1040	4.0	<5	2	<1	<5	<5		
6/11/86	810	4.0							
7/15/86	840	3.0	<5	2	<1	<5	<5	<1	
8/14/86	830	2.2	<5	2	<1	<5	<5	2	
9/15/86	830	2.1	<5	2	1	<5	<5	4	
10/23/86	1035	3.2	1.2	<1	<1	<5	<5	<5	
11/19/86	900	4.7	<5	<1	<1	<5	<5	<1	
12/16/86	1000	6.6	<5	<1	<1	<5	<5	<1	
1/14/87	920	6.8	<5	2	2	6	<5	<1	
2/19/87	950	3.5							
3/17/87	1015	3.3	0.9	2	2.3	3	<1	8	3
4/15/87	930	3.5							
5/13/87	930	2.7							
11/19/87	750	2.8							
12/15/87	915	3.3							
1/14/88	1010	4.6							
3/23/88	1000	2.0							
Minimum		2.0	0.9	<1	<1	3	<1	<1	
Median		3.3	<5	2	1	<5	<5	2	
Maximum		7.0	8	11	13	56	<5	8	
# Data		25	17	17	17	17	17	9	

Table A-9. Mineral Water Quality Data for Brushy Creek, Alameda and Contra Costa Counties

Sampling Location: Latitude 37° 48' 45", Longitude 121° 38' 20"
NW 1/4, NW 1/4, NW 1/4, Sec. 27, T. 2S., R.3E.,
at Armstrong Road.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
11/20/63	1340		54	8.2	880		168				154						509	DWR
1/23/64	1130		47	7.5	1170		244				192						670	DWR
4/9/64	1145		63	8.2	590	1.4	76	55	34	15	64					146	346	DWR
2/3/65	1040		46	7.9	1380	3.4	219	95	88	23	160					315	766	DWR
3/2/65	1100		58	7.7	1340	4.0	221	76	60	28	182					264	756	DWR
1/6/66	1200		54	8.1	1330	4.6	255	56	49	27	192	7.1			235	234	785	DWR
2/2/66	1015		47	8.0	1100	3.9	182	53	37	14	160	7.2			190	152	668	DWR
3/2/66	945		42	8.1	2000		411	76	57	36	295	7.1			275	289	1060	DWR
4/6/66	1645		65	8.2	1120	3.0	186	72	45	23	150	4.7			201	208	629	DWR
5/4/66	1020		66	8.2	700	1.6	100	24	35	16	81	3.6			167	156	400	DWR
11/21/66	1345		62		670	2.2	101											DWR
11/29/66	1110		68		735	1.6	109											DWR
12/6/66	1345		52	7.0	290	1.5	35	12	12	2	43	6.2			67	38	224	DWR
1/23/67	1015		42		685	2.0	102											DWR
2/1/67	1505		56	7.9	811	2.1	111		37	16	106	4.2			158	159	463	DWR
2/17/67	1315		53		1260	3.1	205											DWR
3/3/67	1000		48	8.2	1330	3.8	228	83	37	28	198	5.4			226	208	736	DWR
3/17/67	1330		66		770	1.9	91											DWR
4/7/67	1345		59	8.0	880	2.2	99	56	56	14	104	4.2			217	198	465	DWR
4/21/67	1300		56		1050	2.6	149											DWR
5/10/67	900		58	8.1	1130	2.7	141	59	57	26	141	3.6			303	251	573	DWR
6/5/67	945		58	8.5	1540	1.1	164	17	33	12	52	2.8			135	130	311	DWR
10/9/67	755		61		860	1.6												DWR
10/22/67	740		58		720	1.1	96											DWR
12/4/67	1000		50	7.9	1650	3.3	315	87	81	37	182	9.0			234	354	904	DWR

Table A-9 (continued). Mineral Water Quality Data for Brushy Creek, Alameda and Contra Costa Counties

Sampling Location: Latitude 37° 48' 45", Longitude 121° 38' 20"
NW 1/4, NW 1/4, NW 1/4, Sec. 27, T. 2S., R.3E.,
at Armstrong Road.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
3/8/68	1105		56		1150	5.0	192											DWR
4/29/80	1400		74	8.5	1800	9.3	384	61	49	32	290	4.2	0	274	274	316	1100	DWR
5/5/81	1110		68	8.4	3200	20.0	805		64	48			0	361	361	357		DWR
1/6/82	1305	4.0	45	7.9	900	2.8	170	51	38	17	117	4.5	0	177	177	165	600	DWR
1/28/82	1430	7.0	54	8.3	1100	3.5	185	60	61	25	149	4.3	0	257	257	255	700	DWR
2/15/82	1525	15.0	59	8.3	650	2.1	83	34	35	14	80	5.7	0	162	162	145	404	DWR
3/31/82	1500	170	63	8.2	380	1.0	30	20	24	9	43	4.4	0	123	123	97	240	DWR
Minimum					290	1.0	30	12	12	1.9	43	2.8	0	123	67	38	224	
Median					1100	2.6	168	59	45	23	149	4.5	0	217	210	210	615	
Maximum					3200	20	805	95	88	48	295	9.0	0	361	350	357	1100	
# Data					32	29	31	19	21	21	22	17	6	6	18	21	22	

Table A-10. Mineral Water Quality Data for Mountain House Creek, Alameda County.

Sampling Location: Latitude 37° 44' 58", Longitude 121° 34' 40"
SE 1/4, NE 1/4, NW 1/4, Sec. 19, T.2S., R.4E.,
Mountain House Creek immediately above the aqueduct
at Grant Line Road.

DATE	TIME	FLOW	pH	EC	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS
		cfs		(umhos/cm)						mg/L Total Recoverable						
2/19/87	1015	4.0	7.9	3700	8.0	370	340					0				
3/17/87	1045	3.0	8.2	3550	7.2	540										
4/15/87	1000	2.0	8.3	3750	8.2	560										
5/13/87	1000		8.4	4300	10.0	730										
6/16/87	930		8.4	3800	9.2	793	500									
10/16/87	910			3750	9.9	630	460									
11/19/87	820	0.5		3200	5.8	500	450					0	350	350		
12/15/87	940	1.0	8.2	4550	7.5	640	680									
1/14/88	1040		8.0	4150	6.4	540	540									
3/23/88	1025		8.5	4650	9.5	690	870					17	300	317		
Minimum				3200	5.8	370	340									
Median				3775	8.1	595	500									
Maximum				4650	10.0	793	870									
# Data				10	10	10	7									

Table A-11 Total Recoverable Trace Element Water Quality Data for Mountain House Creek Above the California Aqueduct, Alameda County.

Sampling Location: Latitude 37° 44' 58", Longitude 121° 34' 40"
SE 1/4, NE 1/4, NW 1/4, Sec. 19, T.2S., R.4E.,
Mountain House Creek immediately above the aqueduct.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
2/19/87	1015	7.7							
3/17/87	1045	7.4	7.1	2	0.9	3	<1	8	12
4/15/87	1000	9.0							
5/13/87	1000	15							
6/16/87	930	15							
11/19/87	820	6.5							
12/15/87	940	10							
1/14/88	1040	9.6							
3/23/88	1025	9.3							
Minimum		6.5							
Median		9.3							
Maximum		15							
# Data		9							

Table A-12. Mineral Water Quality Data for Corral Hollow Creek, Alameda and San Joaquin Counties.

Sampling Location: Latitude 37° 39' 28", Longitude 121° 28' 32"
SE 1/4, SE 1/4, NE 1/4, Sec. 24, T.3S., R.4E.,
junction of Corral Hollow Creek and
Corral Hollow Road, 1.5 mi W of I-580.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
					mg/L Total Recoverable												
12/28/55	910	14	7.4	1050	2.8	67	244	77	26	109	5.4	0	170	170	298	660	USGS
1/25/56		100	7.7	539	0.94	24	96	45	14	45	4.0	0	138	138	169	335	USGS
1/27/56	1220	200	8.2	431	0.78	20	69	33	13	34	3.7	0	116	116	136	270	USGS
2/4/56	1230	7.0	7.9	1100	2.6	66	250	83	29	118	5.0	0	228	228	324	720	USGS
3/22/57	750	0.2	8.1	2090	6.6	189	437	93	58	308	5.0	0	346	346	470	1325	DWR
2/4/58	1100	0.7	7.9	2640	7.2	228	779	21	162	341	8.4	0	377	377	720	1800	DWR
4/14/58	1040		8.3	974	1.9	60	202	58	38	99	5.3	0	230	230	300	630	DWR
4/22/58	1030		8.2	1140	3.1	82	234	69	33	131	6.4	0	249	249	154	720	DWR
1/6/59	1320	1.0	8.2	1760	4.2	156	391	61	46	274	7.7	0	303	303	340	1142	DWR
2/25/59	1030		8.4	1220	3.1	85	264	74	29	160	4.4	0	256	256	305	800	DWR
11/6/63	950	1.0	8.3	2240	7.5		572			357		0			347		DWR
2/16/73	1030		8.1	824	1.6	43		59	26	80		0	195	195	256		DWR
2/24/84	1650			1200													RB
3/22/84	1720	3.0		1400	2.8	120	330	87	48	170	3.1	0	250	250			RB
5/17/84	2000			1500													RB
5/31/84	1510			1700													RB
10/17/85	1008		8.0	3000	7.1	290	690	146	85	460		0	180	180		1920	RB
11/19/85	900		7.8	2400	7.2	260	700					0					RB
12/17/85	950		8.6	2300	6.1	250	430					0					RB
1/15/86	815	1.0	7.7	2100	5.0	230	500					0	270	270			RB
2/14/86	845	1.0	8.0	2200	5.3	300	570	122	68	302	6.4	0	380	380	580	1500	RB
2/24/86	1335	5.0	8.0	1500	2.5	150	480	114	19	161	6.8	12	245	257	490	1100	RB
3/17/86	1030		8.1	600	0.7	41	140	52	23	54	4.4	0	150	150	220	420	RB
4/2/86	1005	1.8	8.1	1600	2.8	110	400	101	50	171	5.8	0	290	290	500	1000	RB

Table A-12 (continued). Mineral Water Quality Data for Corral Hollow Creek, Alameda and San Joaquin Counties.

Sampling Location: Latitude 37° 39' 28", Longitude 121° 28' 32"
SE 1/4, SE 1/4, NE 1/4, Sec. 24, T.3S., R.4E.,
junction of Corral Hollow Creek and
Corral Hollow Road, 1.5 mi W of I-580.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
					mg/L Total Recoverable												
4/24/86	1125	1.0	9.0	1600	2.9	110	370		48	190	5.9	0	230	230	390	1000	RB
5/13/86	1125	0.8	8.6	1700	3.5	120	400	53	51	270	4.8	8	230	238	400	1100	RB
6/11/86	850	0.8	8.1	1800	3.9	160	460	50	49	220	6.0	0	260	260	440	1200	RB
7/15/86	920	4.0	8.2	1800	4.5	200	450	44	57	240	6.3	0	240	240	390	1200	RB
8/14/86	915	3.5	8.1	2000	4.8	180	450	100	52	250	6.0	0	320	320	490	1300	RB
9/15/86	915	3.5	8.0	2000	4.8	200	460	140	62	260	6.6	0	380	380	540	1400	RB
10/23/86	1130	3.5	8.0	2100	4.9	190	510	100	56	250	5.6	0	380	380	520	1400	RB
11/19/86	1000	3.5	7.8	2000	4.9	160	340	91	56	220	5.4	0	400	400	520	1100	RB
Minimum				431	0.7	20	69	21	13	34	3.1	0	116	116	136	270	
Medain				2000	4.7	170	435	80	49	220	5.4	0	255	255	400	1120	
Maximum				3200	8.3	360	779	146	162	460	8.4	12	510	510	720	1920	
# Data				42	38	38	36	26	27	28	25	30	29	29	26	24	

Table A-13 Total Recoverable Trace Element Water Quality Data for Corral Hollow Creek, Alameda and San Joaquin Counties.

Sampling Location: Latitude 37° 39' 28", Longitude 121° 28' 32"
SE 1/4, SE 1/4, NE 1/4, Sec. 24, T.3S., R.4E.,
junction of Corral Hollow Creek and
Corral Hollow Road, 1.5 mi W of I-580.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
3/22/84	1720	1.0							
11/19/85	900	1.0	<5	1	2	<5	<1	1	
12/17/85	950	1.0	6	<1	2	<5	<5		
1/15/86	815	1.0	<5	<1	3	<5	<5		
2/14/86	845	1.0	8	<1	2	<5	<5		
2/24/86	1335	5.0	6	3	3	7	<5		
3/17/86	1030	1.0	<5	15	34	11	<5		
4/2/86	1005	2.0	<5	6	<1	<5	<5		
4/24/86	1125	2.0	<5	7	<1	<5	<5		
5/13/86	1125	1.0	17	1	3	<5	<5		
6/11/86	850	1.0							
7/15/86	920	0.9	<5	1	<1	<5	<5	<1	
8/14/86	915	0.8	<5	1	<1	<5	5	1	
9/15/86	915	1.1	<5	1	<1	<5	<5	<1	
10/23/86	1130	0.7	4	8	<1	<5	<5	<5	
11/19/86	1000	1.3	<5	<1	<1	<5	<5	<1	
12/16/86	1100	1.0	<5	<1	<1	<5	<5	<1	
1/14/87	1020	0.9	8	1	5	<5	<5	1	
2/19/87	1040	0.5							
3/17/87	1105	1.2	3.4	<1	<0.5	<1	<1	5	4
4/15/87	1025	0.6							
10/16/87	940	0.4							
11/19/87	840	0.3							
12/15/87	1000	0.4							
1/14/88	1100	0.4							
3/23/88	1050	0.4							
Minimum		0.3	3.4	<1	<0.5	<1	<1	<1	
Median		1.0	<5	1	<1	<5	<5	<1	
Maximum		5.0	17	15	34	11	5	5	
# Data		26	17	17	14	17	17	9	

Table A-14. Mineral Water Quality Data for Lone Tree Creek, San Joaquin County.

Sampling Location: Latitude 37° 37' 03", Longitude 121° 21' 37", SE 1/4, SE 1/4, NE 1/4, Sec. 1, T.4S., R.5E., Bird Rd 1.4 mi S of Vernalis Rd.

DATE	TIME	FLOW	pH	EC	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
		cfs		(umhos/cm)	mg/L Total Recoverable												
1/27/56		40		700	1.7	48	140	52	25	78		7	202	209		484	USGS
2/16/73	1015		7.8	1310	3.1	94		87	44	134		0	280	280	397		DWR
2/24/84	1630			1450													RB
3/22/84	1700			1550	3.0		510	83	75	190	8.2						RB
2/24/86	1410	0.5	8.2	1500	2.2	110	480	113	54	150	11.4	16	230	246	500	1100	RB
3/13/86	945	4.0	8.0	950	1.1	68	240	72	38	103	6.4	12	220	232	320	680	RB
4/2/86	1030	1.0	8.0	1700	2.9	130	470	113	63	171	11.9	0	280	280	580	1200	RB
4/24/86	1145	1.0	8.3	1700	3.1	100	440		64	190	12.0	0	260	260	490	1100	RB
Minimum				700	1.1	48	140	52	25	78	6.4	0	202	209	320	484	
Median				1475	2.9	100	455	85	54	150	11.4	0	245	255	490	1100	
Maximum				1700	3.1	130	510	113	75	190	12.0	16	280	280	580	1200	
# Data				8	7	6	6	6	7	7	5	6	6	6	5	5	

Table A-15 Total Recoverable Trace Element Water Quality Data for Lone Tree Creek, San Joaquin County.

Sampling Location: Latitude 37° 37' 03", Longitude 121° 21' 37", SE 1/4, SE 1/4, NE 1/4, Sec. 1, T.4S., R.5E., Bird Rd 1.4 mi S of Vernalis Rd.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn
		µg/L Total Recoverable						
3/22/84	1700	1.0						
2/24/86	1410	4.0	8	2	2	6	<5	
3/13/86	945	1.0	6	3	7	<5	<5	
4/2/86	1030	2.0	<5	4	<1	<5	<5	
4/24/86	1145	1.7	<5	9	<1	<5	<5	
Minimum		1.0						
Median		1.7						
Maximum		4.0						
# Data		5						

Table A-16. Mineral Water Quality Data for Hospital Creek, San Joaquin and Stanislaus Counties.

Sampling Location: Latitude 37° 36' 09", Longitude 121° 21' 23"
NW 1/4, NW 1/4, SW 1/4, Sec. 7, T.4S., R.6E.,
at the end of Bird Road, 2.5 mi S of Vernalis Road.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
2/24/84	1625				950													RB
3/22/84	1640	0.2	71		950	1.2		282	110	48	85	1.6						RB
5/17/84	1945		65		1000													RB
5/31/84	1535		69		1050													RB
1/27/56		50			475	0.7	20	75	39	18	37		7	172	179		309	USGS
2/15/86	1115			8.4	350	0.45	11	51	32	13	22	4.4	0	110	110	130	230	RB
2/24/86	1425	4.0		8.1	850	0.77	50	230	68	30	70	4.6	0	180	180	290	550	RB
3/17/86	1000	20.0		8.1	550	0.4	27	120	48	24	51	3.3	0	170	170	220	400	RB
4/2/86	1040	2.0		8.4	860	0.94	39	190	63	32	76	4.1	0	210	210	260	600	RB
4/24/86	1210	1.0		8.6	780	1.1	35	200		31	74	4.0	16	160	176	280	500	RB
5/13/86	1200	1.3		9.2	760	1.2	42	200	44	29	93	3.6	8	140	148	240	500	RB
6/11/86	915			8.2	900	1.2	44	230	30	55	79	4.4	8	152	160	310	650	RB
Minimum					350	0.4	11	51	30	13	22	1.6	0	110	110	130	230	
Median					855	0.94	37	200	45	30	74	4.1	0	165	165	260	500	
Maximum					1050	1.2	50	282	110	55	93	4.6	16	210	210	310	650	
# Data					12	9	8	9	8	9	9	8	8	8	8	7	8	

Table A-17 Total Recoverable Trace Element Water Quality Data for Hospital Creek, San Joaquin and Stanislaus Counties.

Sampling Location: Latitude 37° 36' 09", Longitude 121° 21' 23"
NW 1/4, NW 1/4, SW 1/4, Sec. 7, T.4S., R.6E.,
at the end of Bird Road, 2.5 mi S of Vernalis Road.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn
		µg/L Total Recoverable						
3/22/84	1640	1.0						
2/15/86	1115	1.0	<5	21	170	150	14	
2/24/86	1425	1.0	5	3	3	<5	<5	
3/17/86	1000	1.0	<5	3	7	<5	<5	
4/2/86	1040	<1	<5	<1	3	<5	<5	
4/24/86	1210	1.3	<5	3	1	<5	<5	
5/13/86	1200	1.0	<5	1	<1	<5	<5	
6/11/86	915	1.3						
Minimum		<1	<5	<1	<1	<5	<5	
Median		1.0	<5	3	3	<5	<5	
Maximum		1.3	5	21	170	150	14	
# Data		8	6	6	6	6	6	

Table A-18. Mineral Water Quality Data for Ingram Creek, Stanislaus County.

Sampling Location: Latitude 37° 32' 18", Longitude 121° 16' 14"
SE 1/4, SE 1/4, Sec. 35, T.4S., R.6E.,
W of the petrol station, W of I-5 at the Westley exit.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
2/28/84	1610				1520													RB
3/22/84	1610	0.5	73			4.3		510	64	83	240	8.7						RB
5/17/84	1920		73		2000													RB
5/31/84	1600	0.5	83		2200													RB
1/27/56		24			600	2.4	45	88	33	21	75		6	195	201		396	USGS
1/16/86					3800	8.5	280	1500					0	140	140			RB
2/14/86	905	5.0		8.1	850	5.3	71	230	37	33	107	6.2	0	200	200	210	580	RB
2/24/86	1445	3.0		8.2	1300	3.6	95	320	63	52	157	5.7	8	240	248	350	870	RB
3/13/86	900	12.0		7.0	550	1.2	25	120	36	26	62	3.4	0	160	160	200	370	RB
4/2/86	1105	1.3		8.3	1600	4.5	93	400	69	65	197	5.7	44	270	314	440	1100	RB
4/24/86	1230	1.0		9.1	1800	5.3	100	540		66	270	5.1	32	180	212	400	1100	RB
5/13/86	1230	1.5		9.2	2000	6.3	140	770	43	80	290	5.3	60	200	260	470	1400	RB
6/11/86	950	0.5		8.3	2700	7.0	170	990	76	120	400	10.0	110	210	320	630	1900	RB
10/23/86	1240	1.0		8.2	2900	9.0	320	970	97	120	390	7.8	16	330	346	830	2100	RB
11/19/86	1130	1.5		8.3	3100	8.7	200	810	88	130	350	7.3	0	330	330	690	2200	RB
12/16/86	1145	1.5		8.7	2800	7.7	190	800	93	110	320	7.2	0	320	320	600	1900	RB
1/14/87	1105	2.0		8.4	2400		120	760	90	100	380	5.0				550		RB
3/17/87	1145	2.5		8.8	2000	6.0	660											
4/15/87	1215	1.0		8.8	2450	8.3	180											
Minimum					550	1.2	25	88	33	21	62	3.4	0	140	140	200	370	
Median					2000	6.0	140	765	65	80	290	6.0	7	205	255	470	1100	
Maximum					3800	9.0	660	1500	97	130	400	10.0	110	330	346	830	2200	
# Data					18	15	15	14	12	13	13	12	12	12	12	11	11	

Table A-19 Total Recoverable Trace Element Water Quality Data for Ingram Creek Stanislaus County.

Sampling Location: Latitude 37° 32' 18", Longitude 121° 16' 14"
SE 1/4, SE 1/4, Sec. 35, T.4S., R.6E.,
W of the petrol station, W of I-5 at the Westley exit.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
3/22/84	1610	4.0							
1/16/86		18	<5	<1			<5		
2/14/86	905	1.0	6	23	27	45	6		
2/24/86	1445	2.0	6	7	2	9	<5		
3/13/86	900	0.6	7	5	6	<5	<5		
4/2/86	1105	3.0	<5	4	1	<5	<5		
4/24/86	1230	4.3	8	6	<1	<5	<5		
5/13/86	1230	5.0	<5	1	<1	<5	<5		
6/11/86	950	5.5							
10/23/86	1240	4.2	3	<1	<1	<5	<5	<5	
11/19/86	1130	8.7	<5	<1	<1	<5	<5	<1	
12/16/86	1145	5.4	<5	<1	<1	<5	<5	<1	
1/14/87	1105	4.8	<5	1	3	7	<5	2	
3/17/87	1145	2.9	3	1	0.8	<1	<1	5	4
4/15/87	1215	4.4							
Minimum		0.6	3	<1	0.8	<1	<1	<1	
Median		4.3	<5	1	<1	<5	<5	2	
Maximum		18	8	23	27	45	6	5	
# Data		15	12	12	11	11	12	5	

Table A-20. Mineral Water Quality Data for Kern Creek, Stanislaus County.

Sampling Location: Latitude 37°30' 55", Longitude 121° 14' 27"
SE 1/4, SE 1/4, NW 1/4, Sec. 7, T.5S., R.7E.,
Westley exit off I-5, E on Howard Rd, S on Stark Rd,
W on Needham Rd, across aqueduct, under I-5, to upper end of orchard.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS
					mg/L Total Recoverable											
11/19/86	1200	1.0	8.2	6800	12.0	280	3100	170	350	850	9.6	0	540	540	1800	3800
12/16/86	1245	0.8	8.6	5800	10.0	240	4200	160	380	830	14.0	16	340	356	1700	5100
1/14/87	1130	1.0	8.4	5700		290	2600	190	300	950	10.0				1500	
2/19/87	1230	1.0	8.2	5400	8.6	180	1900					0				
3/17/87	1245	0.7	8.4	5450	8.8	250										
4/15/87	1130	0.7	8.4	6200	11.0	240										
Minimum				5400	8.6	180	1900	160	300	830	9.6	0	340	356	1500	3800
Median				5750	10.0	240	2850	170	350	850	10.0	0	440	448	1700	4450
Maximum				6800	12.0	290	4200	190	380	950	14.0	16	540	540	1800	5100
# Data				6	5	6	4	3	3	3	3	3	2	2	3	2

Table A-21 Total Recoverable Trace Element Water Quality Data for Kern Creek, Stanislaus County.

Sampling Location: Latitude 37° 30' 55", Longitude 121° 14' 27"
SE 1/4, SE 1/4, NW 1/4, Sec. 7, T.5S., R.7E.,
Westley exit off I-5, E on Howard Rd, S on Stark Rd,
W on Needham Rd, across aqueduct, under I-5, to upper end of orchard.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		μg/L Total Recoverable							
11/19/86	1200	3.9	<5	4	2	<5	<5	4	
12/16/86	1245	6.5	<5	<1	<1	<5	<5	<1	
1/14/87	1130	7.0	6	4	2	<5	<5	1	
2/19/87	1230	7.5							
3/17/87	1245	6.5	6.1	3	7.5	9	1	11	21
4/15/87	1130	5.0							
Minimum		3.9							
Median		6.5							
Maximum		7.5							
# Data		6							

Table A-22. Mineral Water Quality Data for Del Puerto Creek, Stanislaus County.

Sampling Location: Latitude 37° 28' 35", Longitude 121° 13' 46"
SW 1/4, NW 1/4, NW 1/4, Sec. 29, T.5S., R.7E.,
adjacent to Del Puerto Canyon Road, 2.5 mi W of
the Patterson exit on I-5.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
1/7/52		4.0			890	0.95	29	105	29	91	58		24	458	482		580	USGS
12/29/55		21.6			790	0.80	28	107	34	72	47		11	374	385		512	USGS
1/25/56		180			500	0.34	10	53	24	45	23		9	256	265		314	USGS
3/21/57	1650	1.4	64	8.7	1190	1.5	55	158	17	108	103	3.2	35	470		485	718	USGS
2/4/58	1400	23	54	8.2	766	0.35	23	73	24	70	42	2.3	0	404	404	348	447	USGS
4/14/58	1540		76	8.5	820	0.41	20	136	30	79	42	2.7	6	362	368	400	525	USGS
1/6/59	1540	0.1		7.6	4870	2.2	117	2040	226	357	538	22	0	156	156	2040	4190	DWR
2/3/60	1515	4	55	8.6	1110	1.3	42	175	34	98	81	2.2	26	466	492	488	696	DWR
11/6/63	1300	2	60	8.5	1840	4.0					209					619		DWR
6/27/83	1730				1200	0.57	24	280	30	100	84	2.5	0	318	318			RB
2/24/84	1545				900													
3/22/84	1530	7.0	67		960	1.1	28	220	37	110	75	0	0	390	390			RB
5/17/84	1830		75		1190													RB
5/31/84	1830	1.0	85		1300													RB
11/19/85	1014			8.0	2400	2.5	150	530	63	176	260		33	600	633		1620	RB
12/17/85	1055	2.0		9.0	2060	2.8	110	410										RB
1/15/86	945	3.0		8.5	1500	1.7	68	320					24	420	444			RB
2/14/86	930	100		8.4	600	0.41	16	120	26	50	29	3.1	0	230	230	270	380	RB
2/25/86	800	25.0		8.7	800	0.39	20	130	65	35	38	2.2	32	300	332	400	500	RB
3/13/86	1530			8.4	550	0.37	14	100	30	58	32	1.8	40	220	260	360	410	RB
4/2/86	1125	10.0		8.5	980	0.45	19	160	39	95	53	2.1	0	340	340	500	620	RB
4/24/86	1320	8.0		9.1	1000	0.70	18	185		95	60	2.0	38	300	338	440	580	RB
5/13/86	1330	6.0		9.0	1000	0.89	25	200	16	93	64	2.0	50	300	350	460	660	RB
6/11/86	1015	2.5		8.6	1100	1.1	30	280	38	96	83	4.0	64	340	404	570	790	RB

Table A-22 (continued). Mineral Water Quality Data for Del Puerto Creek, Stanislaus County.

Sampling Location: Latitude 37° 28' 35", Longitude 121° 13' 46"
SW 1/4, NW 1/4, NW 1/4, Sec. 29, T.5S., R.7E.,
adjacent to Del Puerto Canyon Road, 2.5 mi W of
the Patterson exit on I-5.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
7/15/86	1000	4.0		8.6	1500	2.0	44	340	39	120	130	3.1	48	340	388	500	940	RB
8/14/86	1000	3.0		8.5	1700	2.5	57	390	38	120	160	2.9	20	420	440	600	880	RB
9/15/86	950	3.0		8.4	1800	2.7	68	420	55	140	120	3.7	32	480	512	660	1200	RB
10/23/86	1500	3.0		8.4	1800	2.8	130	500	45	140	160	3.4	48	470	518	670	1200	RB
11/9/86	1300	4.0		8.3	1700	2.1	58	350	45	150	120	3.0	26	470	496	710	1200	RB
12/16/86	1340	1.0		8.7	1600	1.6	52	410	39	135	110	3.4	24	415	439	640	1100	RB
1/14/87	1225			8.0	1400		30	230	42	120	120	2.4				580		RB
3/17/87	1400	2.0		8.5	1200	1.1	41											
4/15/87	1235	1.0		8.7	1450	1.6	60											
5/13/87	1115	3.0		8.5	1650	2.4	63											
6/16/87	1030	2.0		8.6	1650	2.8	86	395										
7/14/87	930			7.9	2000	3.2	120	470										
11/19/87	935				2300	3.3	160	480					30	600	630			
12/15/87	1020	1.0		8.3	2550	3.8	170	500										
1/14/88	1200			8.4	2100	2.4	100	490										
3/23/88	1200			8.6	1700	2.1	72	360					6	400	406			
Minimum					500	0.34	10	53	16	35	23	0	0	156	156	270	314	
Median					1350	1.6	48	280	40	98	95	3.0	24	390	398	500	680	
Maximum					4870	4.0	170	2040	226	357	538	4.0	64	600	633	2040	4190	
# Data					40	36	36	33	34	25	26	21	27	27	26	20	22	

Table A-23 Total Recoverable Trace Element Water Quality Data for Del Puerto Creek, Stanislaus County.

Sampling Location: Latitude 37° 28' 35", Longitude 121° 13' 46"
SW 1/4, NW 1/4, NW 1/4, Sec. 29, T.5S., R.7E., adjacent to Del Puerto Canyon Road, 2.5 mi W of the Patterson exit on I-5.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
3/22/84	1530	<1							
11/19/85	1014	0.2	<5	1	1	<5	<1	1	
12/17/85	1055	1.0	<5	<1	2	<5	<5		
1/15/86	945	0.6	<5	<1	6	<5	<5		
2/14/86	930	1.0	<5	27	33	240	8		
2/25/86	800	1.0	<5	2	4	5	<5		
3/13/86	1530	0.4	5	4	9	27	<5		
4/2/86	1125	1.0	<5	2	1	<5	<5		
4/24/86	1320	0.7	<5	4	<1	7	<5		
5/13/86	1330	<1	<5	<1	<1	<5	<5		
6/11/86	1015	0.9							
7/15/86	1000	0.3	<5	1	<1	<5	<5	<1	
8/14/86	1000	0.3	<5	1	<1	<5	<5	1	
9/15/86	950	0.6	<5	<1	<1	<5	<5	<1	
10/23/86	1500	0.2	2	<1	<1	<5	<5	<5	
11/9/86	1300	0.5	<5	<1	<1	<5	<5	<1	
12/16/86	1340	0.4	<5	<1	<1	<5	<5	<1	
1/14/87	1225	0.7	<5	1	2	<5	<5	<1	
3/17/87	1400	0.5	2.1	<1	<0.5	<1	<1	5	1
4/15/87	1235	0.6							
5/13/87	1115	1.2							
6/16/87	1030	0.5							
11/19/87	935	0.3							
12/15/87	1020	0.7							
1/14/88	1200	0.8							
3/23/88	1200	0.5							
Minimum		0.2	2	<1	<0.5	<1	<1	<1	
Median		0.6	<5	1	<1	<5	<5	<1	
Maximum		1.2	5	27	33	240	8	5	
# Data		25	17	17	17	17	17	9	

Table A-24. Mineral Water Quality Data for Black Gulch Creek, Stanislaus County.

Sampling Location: Latitude 37° 27' 50", Longitude 121° 10' 50"
NE 1/4, NW 1/4, NE 1/4, Sec. 34, T.5S., R.7E.,
adjacent to Del Puerto Canyon Road, 1/4 mi W of
the Patterson exit on I-5.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS
					mg/L Total Recoverable											
6/27/83	1745			9900	5.1	140	5600	480	660	900	17	0	540	540		
1/15/86	1010		8.1	6200	3.0	170	4100					0	210	210		
2/14/86	950		7.9	1600	0.62	27	1050	152	79	96	15.2	0	90	90	730	1300
2/25/86	845		7.8	6100	2.6	127	3600	537	451	660	16.5	0	380	380	3100	6100
3/13/86	1600		8.0	4700	2.62	140	3800	482	384	615	17.6	0	310	310	2760	5500
4/2/86	1140	0.3	8.0	9100	2.6	120	3200	482	458	602	17.8	0	350	350	3000	7000
4/24/86	1350		8.5	7600	3.4	110	4200		500	760	16.0	0	340	340	2700	6700
5/13/86	1350		8.7	7200	4.6	100	3700	470	680	480	12.0	0	330	330	3200	7900
6/11/86	1040		8.0	8900	5.9	170	6200	430	1000	1100	20.0	0	300	300	5100	10500
9/15/86	1015		8.0	8900	5.0	270	6300	600	870	1100	12.0	0	520	520	4600	9600
10/23/86	1520		8.0	9200	6.4	240	6400	460	920	1100	11.0	0	520	520	5000	11000
11/19/86	1430	0.5	8.1	7800	5.9	150	5400	390	870	800	10.0	0	280	280	4100	9200
12/16/86	1410		8.4	8100	4.7	130	5800	420	900	800	12.0	0	560	560	4400	8800
1/14/87	1245	1.5	7.8	8200		74	3200	410	790	770	12.0				4200	
2/19/87	1300	0.5	8.0	8400	4.5	120	3700					0				
3/17/87	1420		8.2	8150	4.8	290										
4/15/87	1255		9.0	10800	7.8	180										
10/16/87	1030			9600	3.6	350	5800									
11/19/87	955			9100	4.7	270	5600					0	500	500		
12/15/87	1035		8.2	10650	4.4	300	5600									
1/14/88	1220		8.2	8500	4.0	120	4300									
3/23/88	1215		8.3	9800	5.2	170	7800					<1	310	310		
Minimum				1600	0.62	27	1050	152	79	96	10	0	90	90	730	1300
Median				8500	4.5	150	4800	460	735	765	13.6	0	335	335	3650	7900
Maximum				10800	7.8	350	7800	600	1000	1100	20	<1	560	560	5100	11000
# Data				22	21	22	20	12	13	13	13	16	15	15	12	11

Table A-25 Total Recoverable Trace Element Water Quality Data for Black Gulch Creek, Stanislaus County.

Sampling Location: Latitude 37° 27' 50", Longitude 121° 10' 50"
NE 1/4, NW 1/4, NE 1/4, Sec. 34, T.5S., R.7E., adjacent to Del Puerto Canyon Road, 1/4 mi W of the Patterson exit on I-5.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
1/15/86	1010	44	13	4	8	23	12		
2/14/86	950	12	<5	16	17	42	5		
2/25/86	845	94	14	5	7	25	13		
3/13/86	1600	69	16	5	11	28	<5		
4/2/86	1140	51	11	18	3	18	5		
4/24/86	1350	41	12	21	<1	10	8		
5/13/86	1350	21	<5	4	15	<5	<5		
6/11/86	1040	31							
9/15/86	1015	11	<5	1	<1	<5	<5	11	
10/23/86	1520	8.3	5	<1	1	<5	<5	5	
11/19/86	1430	11	18	3	2	<5	<5	5	
12/16/86	1410	18	11	<1	3	<5	<5	2	
1/14/87	1245	25	15	7	4	9	<5	12	
2/19/87	1300	19							
3/17/87	1420	13	11	<5	1.5	5	<1	10	58
4/15/87	1255	8.6							
10/16/87	1030	71							
11/19/87	955	40							
12/15/87	1035	20							
1/14/88	1220	20							
3/23/88	1215	9.3							
Minimum		8.3	<5	<1	<1	<5	<1	2	
Median		20	11	4	3	9	<5	8	
Maximum		94	16	21	17	42	13	12	
# Data		21	13	13	13	13	13	6	

Table A-26. Mineral Water Quality Data for Salado Creek, Stanislaus County.

Sampling Location: Latitude 37° 25' 22", Longitude 121° 11' 25"
SE 1/4, SW 1/4, SW 1/4, Sec. 10, T.6S., R.7E.,
Oak Flat Rd, 2.1 mi W of I-5.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS
						mg/L Total Recoverable											
2/24/84	1520				1800												
3/22/84	1440	1.2	71		1800	1.2	61	830	110	120	240	0.4	0	250	250		
5/17/84	1900		74		1800		1										
5/31/84	1715		85		1900												
2/14/86	1015	20		8.0	600	0.3	16	180	7	21	47	4.8	0	100	100	190	420
2/25/86	910	4.0		8.1	2200	0.82	70	1200	151	122	216	4.9	8	300	608	840	1700
3/13/86	1500	8.0		8.4	1200	0.71	38	520	92	65	137	3.9	40	240	280	580	1000
4/2/86	1200	3.0		8.5	1900	0.8	53	600	97	99	180	4.3	0	270	270	630	1400
4/24/86	1415	3.0		9.0	2000	1.3	23	910		120	240	4.3	8	230	238	700	1600
5/13/86	1425	1.5		8.9	2400	1.2	61	1000	92	120	290	3.3	8	200	208	740	1800
6/11/86	1100	1.5		8.3	2700	1.3	62	1200	140	140	280	7.0	0	240	240	920	2100
7/15/86	1030	3.0		8.2	2600	1.6	75	1000	79	150	310	4.6	0	240	240	730	2100
8/14/86	1100	2.0		8.2	2800	1.7	78	1300	130	140	310	3.2	0	280	280	870	2200
9/15/86	1030	2.0		8.1	2800	1.6	84	1100	150	140	280	4.3	0	310	310	820	2100
10/23/86	1545	2.0		8.1	2600	1.7	110	1000	110	140	260	3.3	8	290	298	820	2000
11/19/86	1445	2.0		8.0	2000	2.1	86	950	110	130	220	3.4	0	310	310	810	1900
12/16/86	1430	2.4		8.5	2600	1.4	67	970	100	130	270	5.5	0	320	320	840	2000
1/14/87	1315			8.0	2600		48	830	150	140	320	3.8				880	
2/19/87	1330	3.5		8.1	2800	1.5	62	530					0				
3/17/87	1445	2.0		8.3	2950	1.9	121										
4/15/87	1340	1.8		9.0	3350	1.7	100										
5/13/87	1145	1.5		8.0	3750	2.2	100										
3/23/88	1240			8.2	4050	1.7	120	1600					<1	150	150		
Minimum					600	0.3	16	180	41	21	47	3.2	0	100	100	190	420
Median					2600	1.6	70	985	110	130	265	4.3	0	255	275	815	1900
Maximum					4050	2.2	121	1600	151	150	320	7.0	40	320	608	1900	2200
# Data					23	19	20	17	14	15	15	15	16	15	15	14	13

Table A-27 Total Recoverable Trace Element Water Quality Data for Salado Creek, Stanislaus county.

Sampling Location: Latitude 37° 25' 22", Longitude 121° 11' 25"
SE 1/4, SW 1/4, SW 1/4, Sec. 10, T.6S., R.7E.,
Oak Flat Rd, 2.1 mi W of I-5.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
3/22/84	1440	5.0							
2/14/86	1015	2.0	<5	54	40	120	18		
2/25/86	910	7.0	13	2	4	8	<5		
3/13/86	1500	4.7	8	2	9	8	<5		
4/2/86	1200	5.0	<5	5	7	8	<5		
4/24/86	1415	4.7	6	5	1	<5	<5		
5/13/86	1425	4.0	7	8	2	13	<5		
6/11/86	1100	3.5							
7/15/86	1030	3.4	<5	1	<1	<5	<5	<1	
8/14/86	1100	3.2	<5	1	<1	<5	<5	2	
9/15/86	1030	2.9	<5	<1	<1	<5	<5	1	
10/23/86	1545	2.9	5	<1	1	<5	<5	<5	
11/19/86	1445	3.8	<5	<1	<1	<5	<5	<1	
12/16/86	1430	4.7	<5	<1	<1	<5	<5	<1	
1/14/87	1315	5.1	<5	3	3	6	<5	3	
2/19/87	1330	4.5							
3/17/87	1445	4.9	3.2	1	0.9	8	<1	5	12
4/15/87	1340	3.5							
5/13/87	1145	2.1							
3/23/88	1240	1.9							
Minimum		1.9	3.2	<1	0.9	<5	<1	<1	
Median		3.9	<5	1	1	<5	<5	1	
Maximum		7.0	13	54	40	120	18	5	
# Data		20	14	14	14	14	14	8	

Table A-28. Mineral Water Quality Data for Crow Creek, Stanislaus County.

Sampling Location: Latitude 37° 21' 43", Longitude 121° 09' 34"
NW 1/4, NW 1/4, NW 1/4, Sec. 1, T.7S., R.7E.,
W of Beltran Farms, 1/4 mi W of high tension electric lines.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS
						mg/L Total Recoverable											
2/24/84	1500			8.1	3900												
3/22/84	1255	0.3	67	8.4	4200	2.2	160	2700	310	310	720	5.0	0	220	220		
10/17/85	1315			7.8	5600	2.4	180	3500	390	342	696			84	84		5400
11/19/85	1117			7.8	6200	3.9	220	3800									
12/17/85	1155			8.8	5000	3.2	160	2700									
2/25/86	940	1.5		8.1	3600	1.4	120	2000	253	176	460	7.4	0	260	260	1300	3100
4/2/86	1230	1.8		8.3	4000	1.8	140	1900	228	100	446	8.3	0	240	240	1200	3400
5/13/86	1515	0.8		8.8	4400	2.2	120	1400	230	202	410	6.3	0	170	170	1300	4600
6/11/86	1135	2.0		8.3	4500	2.6	110	2600	310	220	530	4.5	0	180	180	1800	4300
7/15/86	1100	1.0		8.1	4800	2.3	160	2900	270	260	600	6.7	0	220	220	1800	4600
8/14/86	1200	1.0		8.1	4800	2.2	160	2500	300	260	570	5.3	0	160	160	1900	4300
9/15/86	1130	1.0		7.8	4800	2.0	160	2600	380	260	580	7.2	0	180	180	1900	4300
10/24/86	1615	2.0		7.9	4600	2.2	190	2600	310	230	500	7.2	0	220	220	1700	4400
11/19/86	1515	2.0		7.9	4700	2.2	140	2500	280	240	480	5.9	0	250	250	1800	4300
12/16/86	1510	2.0		8.4	4900	2.0	78	3200	380	280	530	7.2	0	270	270	1900	2800
1/14/87	1350	2.0		7.9	4800		80	1700	280	250	600	5.0				1800	
2/19/87	1410	2.0		8.0	4900	1.9	96	1800					0				
3/17/87	1515	2.0		8.2	4900	2.0	150										
4/15/87	1410	0.5		8.7	5100	2.3	150										
5/13/87	1215			8.0	5050	2.5	160										
6/16/87	1200	0.8		8.7	4850	2.6	181	3050									
7/14/87	1015			8.3	5600	2.4	240	2800									
8/12/87	945			7.2	6000	2.6	180	3000						160	160		
9/15/87	1030			7.0	5650	2.2	210	2900					6	130	136		
10/16/87	1615	1.0			5500	2.0	250	2800									
12/15/87	1215	0.8		8.1	5000	1.9	160	2200									
3/23/88	1315			8.4	4500	1.7	190	2000					<1	150	150		
Minimum					3600	1.4	78	1400	228	100	410	4.5	0	84	84	1200	2800
Median					4800	2.2	160	2600	290	230	530	7.2	0	220	220	1800	4300
Maximum					6200	3.9	250	3800	390	342	720	8.3	6	270	270	1900	5400
# Data					27	25	26	23	13	13	13	12	14	15	16	11	11

Table A-29 Total Recoverable Trace Element Water Quality Data for Crow Creek, Stanislaus County

Sampling Location: Latitude 37° 21' 43", Longitude 121° 09' 34"
NW 1/4, NW 1/4, NW 1/4, Sec. 1, T.7S., R.7E.,
W of Beltran Farms, 1/4 mi W of high tension electric lines.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		μg/L Total Recoverable							
3/22/84	1440	18							
10/17/85	1315	1.0							
11/19/85	1117	4.0	<5	2	3	<5	<1	2	
12/17/85	1155	6.0	9	18	4	27	<5		
2/25/86	940	14	14	2	4	21	<5		
4/2/86	1230	14	8	6	2	16	<5		
5/13/86	1515	16	<5	1	<1	<5	<5		
6/11/86	1135	13							
7/15/86	1100	8.0	<5	1	<1	<5	<5	<1	
8/14/86	1200	5.9	<5	2	<1	<5	<5	1	
9/15/86	1130	6.0	<5	<1	<1	<5	<5	<1	
10/24/86	1615	8.6	4	<1	<1	<5	<5	<5	
11/19/86	1515	11	<5	<1	<1	<5	<5	<1	
12/16/86	1510	17	<5	<1	<1	<5	<5	<1	
1/14/87	1350	18	<5	5	4	5	<5	<1	
2/19/87	1410	17							
3/17/87	1515	15	4.6	<1	1.5	4	<1	8	27
4/15/87	1410	8.3							
5/13/87	1215	6.5							
6/16/87	1200	4.4							
8/12/87	945	1.3							
9/15/87	1030	0.8							
10/16/87	1615	1.4							
12/15/87	1215	6.6							
3/23/88	1315	3.7							
Minimum		0.8	4	<1	<1	4	<1	<1	
Median		8.0	<5	1	<1	<5	<5	<1	
Maximum		18	14	18	4	27	<5	8	
# Data		25	13	13	13	13	13	9	1

Table A-30. Mineral Water Quality Data for Orestimba Creek, Stanislaus County.

Sampling Location: Latitude 37° 18' 26", Longitude 121° 08' 01"
NW 1/4, SW 1/4, SE 1/4, Sec. 19, T.7S., R.8E.,
Orestimba Creek Rd, .7 mi S of the Calif. Aqueduct.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
1/7/52		11			560	0.27	19	91	45	31	35		0	244	244		363	USGS
1/30/52		82			440	0.20	12	70	44	22	24		0	190	190		286	USGS
3/20/52							12				21		0	189	189			USGS
1/27/53		4.2			710	0.26	24	138	54	38	46		0	275	275		449	USGS
4/21/54		0.6			950	0.86	44	201	56	52	84		0	303	303		609	USGS
12/31/55		253			260	0.15	8	34	27	13	13		0	125	125		174	USGS
1/26/56		800			300	0.15	7	36	31	14	15		2	139	141		195	USGS
3/13/57	920		51	8.1	680	0.56	23	128	29	46	42	2.5	0	230	230	261	400	DWR
3/21/57	1400	3.6	68	8.4	781	0.48	31	131	61	41	53	2.7	0	281	281	322	481	USGS
2/12/58	1100	31	57	8.0	530	0.34	14	60	23	39	30	2.4	0	236	236	217	526	USGS
3/26/58	1000		55	8.4	496	0.25	12	79	45	25	26	2.6	0	210	210	216	321	USGS
4/16/58	1115		71	8.2	675	0.24	19	144	48	41	39	3.2	0	242	242	288	433	USGS
2/18/59	1305		48	8.0	281	0.20	8.5	40	24	12	15	1.8	0	116	116	111	177	DWR
2/15/62	1505		55	7.8	218		6.2	21	21	9.5	9.2	3.2	0	94	94	91	131	DWR
1/23/64	830		43	7.9	521	0.30		81								207		DWR
10/9/79		1		8.0	790	0.40	58	142	62	46	68	5.4	0	192	192	340	567	DWR
6/27/83	1610				1000	0.27	28	300	74	49	65	2.5	0	230	230			RB
2/24/84	1445				1000													RB
3/22/84	1210	7	68		1020	0.39	28	380	86	64	90	2.8	0	220	220			RB
5/17/84	1740		78		1100													RB
5/31/84	1830		76		1000													RB
1/15/86	1110	1.5		8.2	1000	0.42	29	280					0	190	190			RB
2/14/86	1045			8.0	250	0.34	5	30	24	12	14	2.6	0	100	100	150	180	RB
2/25/86	1010			7.9	700	0.17	20	220	57	34	45	3.2	8	200	208	300	460	RB
3/13/86	1430			8.2	450	0.16	12	85	41	22	26	2.2	0	160	160	200	315	RB

Table A-30 (continued). Mineral Water Quality Data for Orestimba Creek, Stanislaus County.

Sampling Location: Latitude 37° 18' 26", Longitude 121° 08' 01"
NW 1/4, SW 1/4, SE 1/4, Sec. 19, T.7S., R.8E.,
Orestimba Creek Rd, .7 mi S of the Calif. Aqueduct.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
4/2/86	1300	30.0		8.4	940	0.33	31	295	66	49	62	3.6	12	220	232	330	635	RB
4/24/86	1515	20.0		8.9	880	0.50	21	250		53	69	3.4	0	210	210	350	590	RB
5/13/86	1545	10.0		9.0	900	0.44	32	280	48	49	140	2.9	8	170	178	340	610	RB
6/11/86	1205	1.5		8.1	1100	0.32	31	360	100	61	73	9.3	0	180	180	400	790	RB
3/17/87	1550	4.0		8.5	1300	0.60	45											
4/15/87	1440	1.5		8.8	1300	0.50	50											
Minimum					218	0.16	5	21	21	9.5	9.2	1.8	0	94	94	91	131	
Median					750	0.32	21	130	45	39	45	2.9	0	200	200	270	433	
Maximum					1300	0.86	58	380	100	64	140	9.3	12	303	303	400	790	
# Data					30	26	27	25	22	23	24	17	25	25	25	16	21	

Table A-31 Total Recoverable Trace Element Water Quality Data for Orestimba Creek Stanislaus County.

Sampling Location: Latitude 37° 18' 26", Longitude 121° 08' 01"
NW 1/4, SW 1/4, SE 1/4, Sec. 19, T.7S., R.8E.,
Orestimba Creek Rd, .7 mi S of the Calif. Aqueduct.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
3/22/84	1210	1.0							
1/15/86	1110	1.0	<5	<1	2	<5	<5		
2/14/86	1045	0.4	<5	12	28	108	<5		
2/25/86	1010	1.0	<5	2	4	<5	<5		
3/13/86	1430	0.4	5	<1	8	7	10		
4/2/86	1300	<1	<5	<1	6	<5	<5		
4/24/86	1515	0.3	<5	6	<1	<5	<5		
5/13/86	1545	<1	<5	<1	<1		<5		
6/11/86	1205	0.6							
3/17/87	1550	1.8	1.5	<1	1.3	1	<1	5	3
4/15/87	1440	1.9							
Minimum		0.3	1.5	<1	<1	1	<1		
Median		1.0	<5	<1	3	<5	<5		
Maximum		1.9	5	12	28	108	10		
# Data		11	8	8	8	7	8		

Table A-32 Total Recoverable Trace Element Water Quality Data for Bennet Valley Creek, Stanislaus County.

Sampling Location: Sec. 9, T.8S, R.8E
Upstream of Interstate 5

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
3/18/87	1430	11	116	<5	6	20	<1	21	220

Table A-33. Mineral Water Quality Data for Garzas Creek, Stanislaus County.

Sampling Location: Latitude 37° 14' 22", Longitude 121° 06' 46"
NE 1/4, NE 1/4, SW 1/4, Sec. 17, T.8S., R.8E.,
Garzas Creek at Sullivan Road, .9 mi W of
Gustine exit on I-5.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
12/29/55		12.6			540	0.43	30	91	46	21	42		0	184			369	USGS
1/26/56		130			360	0.16	10	47	36	15	21		0	159			231	USGS
2/5/58	1000	14.5	58	8.0	562	0.44	22	8.1	20	39	38	2.7	0	222	222	211	324	DWR
4/15/58	1400		80	8.3	773	0.28	36	171	50	43	58	4.0	4	238	242	302	497	USGS
2/9/60	1315	10	59	8.4	724	0.40	31	151	53	33	52	2.6	4	205	214	267	437	DWR
1/23/64	800	2	41	8.0	740	0.41												DWR
2/24/84	1420				1500													RB
3/22/84	1130	0.5	67		1400	0.91	59	570	120	93	180	2.1	0	260				RB
2/14/86	1110			7.9	500	0.35	18	140	35	21	33	3.5	0	130	130	170	320	RB
2/25/86	1050	12.0		7.9	850	0.18	38	280	66	40	67	3.5	8	210	218	320	540	RB
3/13/86	1400	46.0		8.1	550	0.23	18	130	50	26	38	2.5	12	180	192	280	370	RB
4/2/86	1350	5.0		8.4	1000	0.39	52	340	61	52	87	3.6	0	210	210	360	680	RB
4/25/86	810	2.5		8.5	1300	0.80	42	420		61	120	3.3	16	200	216	430	1000	RB
Minimum					360	0.16	10	8.1	20	15	21	2.1	0	130	130	170	230	
Median					740	0.40	30	145	50	35	46	3.3	0	205	215	302	400	
Maximum					1500	0.91	59	570	120	93	180	4.0	16	260	242	430	1000	
# Data					13	12	11	11	10	11	11	9	11	11	8	8	10	

Table A-34 Total Recoverable Trace Element Water Quality Data for Garzas Creek Stanislaus County.

Sampling Location: Latitude 37° 14' 22", Longitude 121° 06' 46"
NE 1/4, NE 1/4, SW 1/4, Sec. 17, T.8S., R.8E.,
Garzas Creek at Sullivan Road, .9 mi W of
Gustine exit on I-5.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb
		µg/L Total Recoverable					
3/22/84	1130	2.0					
2/14/86	1110	0.0	<5	4	19	50	<5
2/25/86	1050	1.0	6	<1	4	<5	<5
3/13/86	1400	0.6	<5	1	6	<5	<5
4/2/86	1350	<1	<5	4	<1	<5	<5
4/25/86	810	0.6	<5	8	<1	<5	<5
Minimum		0	<5	<1	<1	<5	<5
Median		<1	<5	4	4	<5	<5
Maximum		2.0	6	8	19	50	<5
# Data		6	5	5	5	5	5

Table A-35. Mineral Water Quality Data for Quinto Creek, Stanislaus and Merced Counties.

Sampling Location: Latitude 37° 09' 17", Longitude 121° 04' 58"
NE 1/4, SW 1/4, NW 1/4, Sec. 15, T.9S., R.8E.,
immediately W of Howard Ranch on Butts Rd,
1.7 mi W of Calif. Aqueduct.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
1/7/52					1000	1.8	117	107	61	40	108			320	320		635	USGS
1/30/52		5.0			670	0.64	54	77	45	33	59		10	230	230		424	RB
3/20/52		6.0					34				36		6	226	226			RB
1/30/53		0.5			900	0.58	60	141	62	53	70		0	353	353		573	RB
1/26/56		105			350	0.27	17	36	29	17	25		0	160	160		228	RB
3/11/82	1215	3.0	61	8.1	940	1.5	73	103	52	36	96	2.1	0	283	283	278	545	DWR
2/14/86	1150			8.0	450	0.24	29	50	31	23	33	3.2	0	160	160	170	310	RB
2/25/86	1125	8.0		8.1	950	1.1	90	250	58	41	95	3.4	8	270	278	310	570	RB
3/13/86	1330	17.0		8.2	550	0.61	38	74	43	28	50	2.6	16	190	206	240	400	RB
4/25/86	835	2.0		8.7	1200	2.0	100	130		46	120	3.2	16	280	296	310	710	RB
5/13/86	1645	1.0		8.7	950	1.4	81	110	23	40	120	2.0	16	260	276	280	560	RB
3/18/87	1330	1.5		8.1	1350	2.0	170											
Minimum					350	0.24	17	36	23	17	25	2.0	0	160	160	170	228	
Median					940	1.1	68	105	45	38	70	2.9	7	245	276	280	560	
Maximum					1350	2.0	170	250	62	53	120	3.4	16	353	353	310	710	
# Data					11	11	12	10	9	10	11	6	10	11	11	6	10	

Table A-36 Total Recoverable Trace Element Water Quality Data for Quinto Creek, Stanislaus and Merced Counties.

Sampling Location: Latitude 37° 09' 17", Longitude 121° 04' 58"
NE 1/4, SW 1/4, NW 1/4, Sec. 15, T.9S, R.8E,
immediately W of Howard Ranch on Butts Rd,
1.7 mi W of Calif. Aqueduct.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
					Total Recoverable				
2/14/86	1150	0.6	<5	4	9	11	<5		
2/25/86	1125	1.0	6	<1	4	<5	<5		
3/13/86	1330	0.6	<5	<1	5	<5	<5		
4/25/86	835	<1	<5	2	2	<5	<5		
5/13/86	1645	<1	<5	2	<1	<5	<5		
3/18/87	1330	1.0	2.8	1	<0.5	1	<1	6	3
Minimum		0.6	2.8	<1	<0.5	1	<1		
Median		<1	<5	1	3	<5	<5		
Maximum		1.0	6	4	9	11	<5		
# Data		6	6	6	6	6	6		

Table A-37. Mineral Water Quality Data for Romero Creek, Stanislaus and Merced Counties.

Sampling Location: Latitude 37° 07' 18", Longitude 121° 04' 07"
NE 1/4, NE 1/4, SE 1/4, Sec. 27, T.9S., R.8E.,
N side of McCabe Rd, 1.1 mi W of Calif. Aqueduct.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
					mg/L Total Recoverable												
1/23/52		3.0		650	1.1	71	33	41	24	52		8	200	228		410	USGS
2/14/86	1230	15	8.0	1000	1.2	160	110	65	39	101	4.8	0	240	240	330	600	RB
2/25/86	1140	6.0	9.2	890	1.1	120	80	61	33	82	3.6	8	240	248	290	540	RB
3/13/86	1305	16.0	8.1	500	0.63	47	36	40	21	42	3.2	0	180	180	200	300	RB
4/25/86	900	3.0	8.8	860	1.5	96	54		29	88	2.8	8	240	248	270	520	RB
5/13/86	1715	0.8	8.8	950	1.7	110	65	33	35	140	3.1	32	240	272	270	540	RB
6/11/86	1305	1.5	8.5	1100	2.3	160	75	57	43	120	2.7	8	270	278	300	620	RB
2/19/87	1600	2.0	8.3	1300	2.2	230	94					0					
3/18/87	1300	3.5	8.3	1300	1.8	230											
4/15/87	1700		8.2	1450	2.4	250											
Minimum				500	0.63	47	33	33	21	42	2.7	0	180	180	200	300	
Median				1000	1.7	160	75	57	34	95	3.2	8	240	248	280	540	
Maximum				1450	2.4	250	110	65	43	140	4.8	32	270	278	330	620	
# Data				10	10	10	8	6	7	7	6	8	7	7	6	7	

Table A-38 Total Recoverable Trace Element Water Quality Data for Romero Creek, Stanislaus and Merced Counties.

Sampling Location: Latitude 37° 07' 18", Longitude 121° 04' 07"
NE 1/4, NE 1/4, SE 1/4, Sec. 27, T.9S., R.8E.,
N side of McCabe Rd, 1.1 mi W of Calif. Aqueduct.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		μg/L Total Recoverable							
2/14/86	1230	1.0	<5	2	4	<5	<5		
2/25/86	1140	1.0	<5	<1	5	<5	<5		
3/13/86	1305	0.3	<5	<1	6	<5	<5		
4/25/86	900	<1	<5	5	<1	<5	<5		
5/13/86	1715	<1	<5	4	<1	<5	<5		
6/11/86	1305	0.4							
2/19/87	1600	1.1							
3/18/87	1300	0.8	2.2	<1	<0.5	<1	<1	4	2
4/15/87	1700	4.4							
Minimum		0.3	2	<1	<0.5	<1	<1		
Median		<1	<5	1	<1	<5	<5		
Maximum		4.4	<5	5	6	<5	<5		
# Data		9	6	6	6	6	6		

Table A-39. Mineral Water Quality Data for Los Banos Creek, Merced and San Benito Counties.

Sampling Location: Latitude 36° 57' 25", Longitude 120° 01' 05"
SW 1/4, SW 1/4, SW 1/4, Sec. 20, T.11S., R.9E.,
immediately above Los Banos Reservoir.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
1/8/52		6.0			325	0.27	17	28	22	14	22		0	132	132		204	USGS
1/30/52		20			390	0.32	20	36	27	19	26		0	158	158		244	USGS
3/20/52		8.0			260	0.33	9	19	22	12	14		0	120	120		164	USGS
1/30/53					550	0.46	37	47	40	23	41		0	223	223		335	USGS
4/20/54		0.7			900	1.6	135	87	52	34	108		0	272	272		583	USGS
5/3/55		3.6			510	0.77	22	48	43	24	31		0	232	232		327	USGS
12/31/55		450			210	0.18	8	16	17	8.2	11		0	87	87		128	USGS
4/11/56		0.5			700	0.75	69	81	56	32	53		0	253	253		455	USGS
3/20/57		1.2	64	8.1	1130	2.2	115	112	72	48	110	2.2	0	413	413	378	669	USGS
2/6/58	1000	68.0	53	7.5	329	3.0	15	31	25	15	21	2.4	0	148	148	124	217	USGS
2/27/62				8.4	535	6.0	44	65	37	21	44	2.2	0	166	166	177	335	DWR
3/22/84	1000	8.0	57		450	0.78		57	51	29	37	3.2						RB
6/1/84	1200	4.0	81		540		39	52	57	30	33	4.1	0	200	200			RB
11/19/85	1335			7.4	2200	1.8	330	430	87	65	262		0	180	180		1320	RB
2/14/86	1340			8.1	600	0.56	50	120	38	29	54	3.4	16	160	176	210	390	RB
2/25/86	1300			9.2	550	0.50	40	90	36	25	45	3.4	0	160	160	190	350	RB
3/13/86	1030			7.9	500	0.51	38	68	35	22	39	3.3	0	190	190	180	310	RB
6/11/86	1400	1.5		8.6	580	0.40	34	57	47	30	35	3.8	16	160	176	220	360	RB
9/15/86	1655	3.0		7.6	550	0.45	41	74	38	24	51	3.6	0	160	160	180	320	RB
2/20/87	700	3.0		7.0	650	1.2	42	79					0					RB
Minimum					210	0.28	8	16	17	8.2	11	2.2	0	87	87	124	128	
Median					550	0.51	39	61	38	24	39	3.4	0	160	160	185	335	
Maximum					2200	2.2	330	430	87	65	262	4.1	16	413	413	378	1320	
# Data					20	19	19	20	19	19	19	10	19	18	18	8	17	

Table A-40 Total Recoverable Trace Element Water Quality Data for Los Banos Creek, Merced and San Benito Counties.

Sampling Location: Latitude 36° 57' 25", Longitude 120° 01' 05"
SW 1/4, SW 1/4, SW 1/4, Sec. 20, T.11S., R.9E.,
immediately above Los Banos Reservoir.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn
		µg/L Total Recoverable						
3/22/84	1000	<1						
11/19/85	1335	4.0	<5	3	2	<5	<1	1
2/14/86	1340	0.4	<5	<1	1	<5	<5	
2/25/86	1300	0.6	<5	<1	5	7	<5	
3/13/86	1030	1.0	<5	1	9	10	<5	
6/11/86	1400	0.4						
9/15/86	1655	0.6	<5	<1	<1	<5	<5	<1
2/20/87	700	1.2						
Minimum		0.4	<5	<1	<1	<5	<1	
Median		<1	<5	<1	2	<5	<5	
Maximum		4.0	<5	3	9	10	<5	
# Data		8	5	5	5	5	5	

Table A-41. Mineral Water Quality Data for Salt Creek, Merced County.

Sampling Location: Sec. 18, T.11S., R.10E.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
3/20/52					8800	25	2700	550	160	83	1800		5	220	225		5600	USGS

Table A-42. Mineral Water Quality Data for Ortigalita Creek, Merced County.

Sampling Location: Latitude 36° 55' 40", Longitude 120° 55' 15"
NW 1/4, SE 1/4, SW 1/4, Sec. 31, T.11S., R.10E.,
0.8 mi S of Arbura Rd.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
11/8/62	1500	3.0		8.3	4730	4.1	876	1040	103	222	655	3.6	0	385	385	854	3120	DWR
3/14/84					2790	3.1												USBR
3/22/84	1640	2.0	69		2600	3.4		510	62	100	440	4.7						RB
5/25/84					4150	5.1												USBR
6/1/84	800		63		3000		460	660	56	118	500	4.8	0	476	476			RB
6/19/84					4370	5.1												USBR
7/23/84					5560	6.7												USBR
8/21/84					5850	7.0												USBR
9/25/84					6010	7.5												USBR
10/15/84					5360	6.3												USBR
11/13/84					4830	5.5												USBR
12/11/84					4590	5.0												USBR
1/15/85					4500	5.2												USBR
3/13/85					4760	5.5												USBR
4/9/85					5320	6.7												USBR
4/22/85					4540	5.1												USBR
5/8/85					6550	7.0												USBR
6/4/85					7020	8.5												USBR
10/17/85	755			8.0	5800	6.0	980	1400	198	283	795			210	210		4200	RB
11/19/85	1412			8.2	5700	7.4	980	1500										RB
12/17/85	1425			8.7	5600	5.8	1000	1200										RB
1/15/86	1700	0.5		8.0	5600	5.8	910	1500					0	340	340			RB
2/14/86	1350	0.6		8.2	8100	9.4	1800	2800	266	391	1380	16.7	0	440	440	2000	7100	RB
2/25/86	1340	0.5		8.6	5550	6.3	1100	1650	173	265	885	4.8	0	380	380	1450	4150	RB
2/26/86					6440	7.0												USBR
3/13/86	1115	1.0		7.7	5600	7.7	1100	1600	226	296	885	5.3	0	500	500	1760	4500	RB
4/25/86	1545	0.7		8.0	5700	5.7	1250	1600	190	284	798	4.5	0	410	410	1500	4300	RB

Table A-42 (continued). Mineral Water Quality Data for Ortigalita Creek, Merced County.

Sampling Location: Latitude 36° 55' 40", Longitude 120° 55' 15"
NW 1/4, SE 1/4, SW 1/4, Sec. 31, T.11S., R.10E.,
0.8 mi S of Arbura Rd.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
5/15/86	1030	1.0		8.5	5600	5.6	840	1200		260	800	4.1	0	370	370	1550	4300	RB
6/11/86	1510	0.8		8.1	6000	5.9	1000	1600	180	260	940	7.6	0	380	380	1500	4500	RB
7/15/86	1245	1.0		8.0	5700	6.1	1000	1600	110	290	810	3.7	0	400	400	1400	4400	RB
8/14/86	1345	1.0		8.2	5900	6.0	940	1500	190	270	770	3.9	0	400	400	1600	4300	RB
9/15/86	1430	1.0		7.9	5900	6.2	1000	1600	240	300	910	6.2	0	450	450	1700	4400	RB
10/24/86	1145	1.5		7.9	5800	6.3	940	1300	160	270	690	4.4	0	470	470	1600	4200	RB
11/21/86	1130	2.0		7.2	4900	6.1	890	1600	120	280	820	6.0	0	460	460	1600	4300	RB
12/17/86	845	1.8		8.0	5000	6.0	1000	1400	160	280	600	5.7	0	460	460	1500	3700	RB
1/15/87	845	2.5		7.6	5700		680	1000	180	300	900	3.6				1500		RB
2/20/87	740	2.0		7.5	6400	5.9	680	1000					0					RB
3/17/87	1730	2.0		7.9	5900	5.3	980											RB
4/16/87	800	1.8		8.5	5950	6.5	915											RB
5/13/87	1500	1.5		8.1	5900	5.8	960											RB
6/16/87	1400	1.5		8.1	5700	6.6	1077	1460										RB
7/14/87	1330	1.0		7.8	5800	5.8	1100	1600										RB
8/12/87	1130	1.0		8.0	5800	5.8	750	1400							430			RB
9/15/87	1315	1.0		8.0	5650	5.5	860	1300					2	210	212			RB
10/16/87	1500	1.5			5850	5.8	880	1500										RB
11/19/87	1230	1.8			5450	5.8	750	1300					0	480	480			RB
12/15/87	820	1.0		8.1	5750	5.7	750	1400										RB
1/14/88	815			7.8	5800	5.5	720	1300										RB
3/23/88	1545			8.4	5050	5.1	760	1200					12	260	272			RB
Minimum					2600	3.1	460	510	56	100	440	3.6	0	210	210	854	3120	
Median					5700	5.7	950	1460	173	260	815	4.8	0	400	405	1550	4300	
Maximum					8100	9.4	1800	2800	266	391	1380	16.7	12	500	500	2000	7100	
# Data					49	47	32	30	16	17	17	17	19	19	19	14	14	

Table A-43 Total Recoverable Trace Element Water Quality Data for Ortigalita Creek, Merced County.

Sampling Location: Latitude 36° 55' 40", Longitude 120° 55' 15"
NW 1/4, SE 1/4, SW 1/4, Sec. 31, T.11S., R.10E.,
0.8 mi S of Arbura Rd.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	Sampler
		µg/L Total Recoverable								
3/14/84		5.0	6	5	4					USBR
3/14/84		5.0	6	5	4					USBR
5/25/84		<1	7	7	4					USBR
6/19/84		<1	7	5	<1					USBR
7/23/84		2.0	4							USBR
8/21/84		<1	3		1					USBR
9/25/84		6.0	4	3	4					USBR
10/15/84		7.0	6							USBR
11/13/84		3.0	2	13	<1					USBR
12/11/84		2.0	<1	7	3					USBR
1/15/85		2.0	5	4	6					USBR
3/13/85		2.0	4	4						USBR
4/9/85			6							USBR
4/22/85		2.0	4	3	3					USBR
5/8/85		2.0	5	7	10					USBR
6/4/85		<1	5	8	2					USBR
10/17/85	755	4.0								RB
11/19/85	1412	5.0	<5	3	4	<5	<1	3		RB
12/17/85	1425	5.0	22	4	7	5	<5			RB
1/15/86	1700	6.0	16	3	4	28	6			RB
2/14/86	1350	4.0	15	6	17	39	13			RB
2/25/86	1340	10.0	17	<1	6	48	<5			RB
2/26/86		2.0		9						USBR
3/13/86	1115	4.4	18	2	9	55	<5			RB
4/25/86	1030	5.0	17	16	2	<5	11			RB
5/15/86	920	5.0	<5	20	2	7	14			RB
6/11/86	1510	5.6								RB
7/15/86	1245	5.1	<5	<1	<1	<5	<5	<1		RB
8/14/86	1345	5.0	<5	2	1	<5	6	1		RB
9/15/86	1430	4.5	<5	<1	1	<5	<5	1		RB
10/24/86	1145	4.9	4	<1	2	<5	<5	<5		RB
11/21/86	1130	5.6	<5	<1	<1	<5	<5	<1		RB
12/17/86	845	5.5	<5	<1	2	<5	<5	<1		RB
1/15/87	845	5.8	<5	2	5	<5	<5	7		RB
2/20/87	740	5.6								RB
3/17/87	1730	5.7	4.1	<1	2.5	<1	<1	6	12	RB
4/16/87	800	5.9								RB
5/13/87	1500	6.3								RB
6/16/87	1400	6.2								RB
8/12/87	1130	5.6								RB
9/15/87	1315	5.6								RB
10/16/87	1500	5.8								RB
11/19/87	1230	5.4								RB
12/15/87	820	5.6								RB
1/14/88	815	5.6								RB
3/23/88	1545	5.6								RB
Minimum		<1	<1	<1	<1	<1	<1	<1		
Median		5	<5	3	3	<5	<5	1		
Maximum		10	22	20	17	55	14	7		
# Data		44	31	28	27	16	16	9		

Table A-44. Mineral Water Quality Data for Little Panoche Creek Above Panoche Reservoir, Merced, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 45' 29", Longitude 120° 50' 46"
SW 1/4, NE 1/4, Sec. 35, T.13S., R.10E.,
50 ft W of Barneich Ranch Rd, 7.5 mi W of I-5.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
5/22/30		0.2			5900	19	1810	454	278	146	920			333	333		3790	USGS
1/7/52		2.0			2000	6.0	475	173	93	36	275		0	186	186		1170	USGS
1/30/52		0.2			3900	15	960	375	182	114	580		0	458	458		2480	USGS
3/19/52		6.0			850	1.4	106	97	73	27	83		14	248	262		541	USGS
1/27/54		0.8			5950	16	1760	486	239	116	985		0	400	400		3820	USGS
1/26/56		30			650	1.5	86	65	53	18	70		3	200	203		422	USGS
4/10/56		1.0			4650	17	1400	363	116	102	855		0	291	291		3020	USGS
3/19/57	1030	0.4	63	8.0	6230	17	1770	340	160	109	1040	10	0	353	353	846	3630	USGS
2/10/58	1000	2.0	55	7.7	3930	10	900	380	27	161	577	10	0	350	350	730	2260	USGS
2/19/58	1000	3.0		8.4	3180	11	780				480		0	302	302	432		USGS
3/17/58	1645			7.7	710	1.5	82	61	54	22	69	4.6	0	240	240	224	432	USGS
4/15/58	1655	16	77	8.0	1310	3.5	235	108	32	54	161	5	0	247	247	300	726	USGS
6/3/58	1930	4.0		7.9	2340	8.0	516	169	67	51	362	4.4	0	320	320	376	1350	DWR
1/7/59	1305	1.0		8.0	3480	13	830	214	88	59	575	20	0	381	381	461	2000	DWR
4/22/59	1500	14		8.0	3240	14	696	114	145	152	196	4.3	0	390	390	989	1530	DWR
2/3/60	1040	3.0	56	7.9	2880	12	639	190	128	57	404	5.7	0	438	438	556	1670	DWR
3/7/62	1515	0.1	74	7.7	5580	9.5	1400	346	133	92	910	20	0	396	396	710	3110	DWR
2/1/63	1400	3.0	54	8.3	3470	14	833	222	126	76	515	12	0	410	410	627	2070	DWR
4/6/63	1130	0.5		8.0	5800	16	1640	362	133	98	1075	7.5	0	412	412	735	3940	DWR
3/22/84					950	3.5		105	67	29	130	1.1	0					RB
3/23/84	1300	2.0	60		1100	3.6	150	120	64	29	140	2.2	0	267	267			USGS
5/17/84	930		62		970													RB
6/1/84	900	2.0	65		1000		140	100	30	26	123	3.2	0	340	340			RB
10/17/85	1000			8.0	1650	5.1	220	120	102	39	180			110	110		930	RB
11/19/85	1514			7.9	1700	6.8	330	150										RB
12/17/85	1540	1.5		8.9	1900	7.2	380	130										RB
1/15/86	1500	1.5		8.3	1800	7.1	390	140					0	170	170			RB
2/15/86	1350			8.5	700	1.4	77	120	48	22	66	4.8	0	170	170	210	440	RB
2/25/86	1500	0.5		8.8	2000	8.9	460	150	109	45	246	4.1	0	260	260	470	1200	RB

Table A-44 (continued). Mineral Water Quality Data for Little Panoche Creek Above Panoche Reservoir, Merced, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 45' 29", Longitude 120° 50' 46"
SW 1/4, NE 1/4, Sec. 35, T.13S., R.10E.,
50 ft W of Barneich Ranch Rd, 7.5 mi W of I-5.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
3/13/86	940	2.0		8.1	1200	4.4	200	130	89	36	134	3.2	20	250	270	380	750	RB
4/3/86	730	0.8		7.6	2100	8.5	520	170	110	46	246	4.1	0	230	230	460	1200	RB
4/25/86	1200	1.0		8.7	1800	6.9	300	130		41	210	3.7	0	200	200	370	1100	RB
6/11/86	1630	3.0		8.6	1700	5.7	300	120	86	40	210	5.8	50	200	250	340	940	RB
7/15/86	1400	3.0		8.4	1500	5.2	280	120	48	38	180	3.5	0	180	180	230	860	RB
8/14/86	1440	3.0		8.3	1500	5.1	290	130	64	34	180	2.8	0	100	100	300	810	RB
9/15/86	1555	1.0		8.1	1600	5.6	280	120	90	39	200	3.8	0	230	230	340	910	RB
10/25/86	1030	1.0		8.2	1700	6.4	340		63	37	180	2.8	0	290	290	410	1000	RB
11/21/86	1305	1.3		7.6	1400	6.6	320	120	47	38	210	4.0	0	290	290	240	1000	RB
12/17/86	1015	1.0		8.4	1700	6.4	280	110	60	39	180	3.9	0	300	300	280	930	RB
1/15/87	945	1.8		8.2	1700		220	100	110	42	230	3.2				420		RB
2/20/87	1100	4.0		8.0	1700	6.4	270	120					0					RB
3/18/87	745	6.0		7.9	1600	4.4	300											RB
4/16/87	925	5.0		9.0	1600	5.2	240											RB
5/13/87	1630	3.0		8.3	1500	5.4	250											RB
6/16/87	1530	3.0		8.6	1350	4.8	260	130										RB
7/14/87	1430	1.8		8.1	1500	4.7	280	180										RB
8/12/87	1330	1.8		8.2	1400	4.9	200	100							210			RB
9/15/87	1115	2.0		8.3	1350	4.8	250	120					8	160	168			RB
10/16/87	1415	1.8			1550	5.5	280	120										RB
11/19/87	1345	3.0			1750	5.7	290	110					0	300	300			RB
12/15/87	930	3.5		8.4	1900	5.7	880	240										RB
1/14/88	935			7.9	1950	6.5	310	110										RB
3/23/88	920			8.2	1950	6.9	340	120					<1	130	130			RB
Minimum					650	1.4	77	61	27	18	66	1.1	0	100	100	210	422	
Median					1700	6.4	300	130	88	40	210	4.1	0	290	290	425	1000	
Maximum					6230	19	1810	486	278	161	1075	20	50	458	458	989	3940	
# Data					53	50	51	47	34	35	36	27	38	38	38	25	31	

Table A-45. Mineral Water Quality Data for Little Panoche Creek Below Little Panoche Reservoir, Merced, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 47' 07", Longitude 120° 47' 15"
NE 1/4, NE 1/4, SE 1/4, Sec. 20, T.13S., R.11E., immediately below Little Panoche Reservoir.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
					mg/L Total Recoverable												
3/14/84				1950	6.3												USBR
5/22/84				2280	8.0												USBR
6/19/84				2150	9.0												USBR
7/24/84				2860	11												USBR
8/21/84				3190	12												USBR
9/26/84				3320	14												USBR
10/15/84				3290	14												USBR
11/13/84				3160	13												USBR
12/12/84				3050	12												USBR
1/15/85				2870	12												USBR
2/11/85				2830	11												USBR
3/11/85				2830	11												USBR
4/8/85				2830	12												USBR
5/7/85				3240	12												USBR
6/3/85				3210	13												USBR
7/8/85				3780	16												USBR
11/4/85				4800	17												USBR
11/19/85	1455		7.4	4200	13	1000	270	110	82	645		0	380	380		2400	RB
12/5/85				3760													USBR
12/17/85	1510	1.5	8.7	3700	7.1	860	200										RB
1/6/86				3630													USBR
1/15/86	1430	1.8	8.0	3300	15	830	240					0	320	320			RB
2/15/86	1315	1.5	8.0	3400	16	900	300	109	70	550	8.3	0	360	360	500	2000	RB
2/25/86	1445	1.5	8.6	3000	13	750	210	108	63	470	6.9	8	300	308	480	1700	RB
2/26/86				3110	13												USBR

Table A-45 (continued). Mineral Water Quality Data for Little Panoche Creek Below Little Panoche Reservoir, Merced, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 47' 07", Longitude 120° 47' 15"
NE 1/4, NE 1/4, SE 1/4, Sec. 20, T.13S., R.11E.,
immediately below Little Panoche Reservoir.

DATE	TIME	FLOW cfs	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
					mg/L Total Recoverable												
3/13/86	915	1.5	7.9	2900	13.1	720	210	113	65	450	7.5	0	350	350	500	1800	RB
4/25/86	1130	2.0	8.5	2300	8.2	420	160		45	310	6.4	0	270	270	360	1400	RB
5/19/86				2620	10	10											USBR
6/11/86	1600	0.8	8.2	2750	11	600	180	91	55	410	7.1	0	300	300	480	1650	RB
11/21/86	1245	1.5	7.8	3400	16	950	350	88	80	700	9.6	0	360	360	540	2400	RB
12/17/86	940	3.0	8.1	3800	18	810	200	78	74	530	8.7	0	360	360	500	2400	RB
1/15/87	1015	1.0	7.4	3500		650	140	100	79	620	6.0				480		RB
2/20/87	840	1.0	7.6	3400	13	670	160					0					RB
3/18/87	730	1.0	7.7	3400	10.8	780											RB
4/16/87	910	5.0	8.9	3450	14	760											RB
5/13/87	1600	4.0	8.0	3500	14	820											RB
6/16/87	1500	2.0	8.0	3850	11.1	1101	215										RB
11/19/87	1330	0.8		5300	18	1200	310					0	400	400			RB
12/15/87	900	3.0	8.0	4600	6.5	300	130										RB
1/14/88	955		7.7	4200	15	785	180										RB
3/23/88	900		8.2	3800	15	820	230					18	250	268			RB
Minimum				1950	6.3	300	130	78	45	310	6.0	0	250	268	360	1400	
Median				3300	13	798	210	104	74	550	7.3	0	350	350	490	1900	
Maximum				5300	18	1200	350	113	82	700	9.6	18	400	400	540	2400	
# Data				41	38	20	17	8	9	9	8	12	11	11	8	8	

Table A-46 Total Recoverable Trace Element Water Quality Data for Little Panoche Creek Above Little Panoche Reservoir, Merced, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 45' 29", Longitude 120° 50' 46"
SW 1/4, NE 1/4, Sec. 35, T.13S., R.10E.,
50 ft W of Barneich Ranch Rd, 7.5 mi W of I-5.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
10/17/85	1000	0.3							
11/19/85	1514	0.4	<5	1	2	<5	<1	1	
12/17/85	1540	0.3	<5	<1	3	<5	<5		
1/15/86	1500	0.5	<5	<1	1	10	<5		
2/15/86	1350	1.0	<5	43	160	46	5		
2/25/86	1500	1.0	7	<1	4	<5	<5		
3/13/86	940	0.3							
4/3/86	730	<1	5	<1	7	<5	<5		
4/25/86	1200	<1	<5	3	<1	<5	<5		
5/14/86	805	<1	5	5	4	<5	<5		
6/11/86	1630	0.7							
7/15/86	1400	0.4	<5	1	<1	<5	<5	<1	
8/14/86	1440	0.6	<5	1	<1	<5	<5	<1	
9/15/86	1555	1.2	<5	<1	<1	<5	<5	<1	
10/25/86	1030	0.5	3	<1	<1	<5	<5	<5	
11/21/86	1305	0.8	<5	<1	<1	<5	<5	<1	
12/17/86	1015	0.5	<5	<1	<1	<5	<5	<1	
1/15/87	945	0.8	<5	2	3	6	<5	2	
2/20/87	1100	0.6							
3/18/87	745	0.9	3	<1	0.7	<1	<1	5	2
4/16/87	925	0.4							
5/13/87	1630	1.2							
6/16/87	1530	0.5							
8/12/87	1330	0.7							
9/15/87	1115	1.4							
10/16/87	1415	0.5							
11/19/87	1345	0.4							
12/15/87	930	0.3							
1/14/88	935	0.4							
3/23/88	920	0.5							
Minimum		0.3	3	<1	0.7	<1	<1	<1	
Median		0.5	<5	<1	<1	<5	<5	<1	
Maximum		1.4	7	43	160	46	5	5	
# Data		30	16	16	16	16	16	9	

Table A-47 Total Recoverable Trace Element Water Quality Data for Little Panoche Creek Below Little Panoche Reservoir, Merced, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 47' 07", Longitude 120° 47' 15"
NE 1/4, NE 1/4, SE 1/4, Sec. 20, T.13S., R.11E.,
immediately below the Panoche Reservoir.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	Sampler
		µg/L Total Recoverable								
3/14/84		2	3	3	3	<1	<1			USBR
5/22/84		<1	3	3	3	<1	<1			USBR
6/19/84		<1	2	4	3	13	<1			USBR
7/24/84		1	2		<1	14	<1			USBR
8/21/84		<1	<1		5	26	5			USBR
9/26/84		<1	2	8	4	7	<1			USBR
10/15/84		<1	<1	3	<1	10	4			USBR
11/13/84		<1	<1	3	<1	12	1			USBR
12/12/84		<1	4	3	2	18	<1			USBR
1/15/85		1	<1	1	1	15	1			USBR
2/11/85		<1	<1	<1	6	8	1			USBR
3/11/85		<1	2	1	3	15	<1			USBR
4/8/85		<1	<1	2	2	4	3			USBR
5/7/85		<1	1	5	3	5	<1			USBR
6/3/85		<1	4	2	1	7	4			USBR
7/8/85		<1	3	3	8	6				USBR
11/4/85		<1	1	2	10	2				USBR
11/19/85	1455	0.4	<5	1	2	<5	<1	<1		RB
12/5/85		<1	7	2	6	3	2			USBR
12/17/85	1510	0.3	<5	<1	2	15	<5			RB
1/6/86		<1	2	<1		9				USBR
1/15/86	1430	0.5	<5	1	<1	17	6			RB
2/15/86	1315	0.4	<5	1	4	19	9			RB
2/25/86	1445	0.6	5	<1	4	16	<5			RB
2/26/86		<1				<1				USBR
3/13/86	915	0.3	6	<1	9	10	<5			RB
4/25/86	1130	<1	6	<1	<1	<5	6			RB
5/14/86	730	<1	<5	2	<1	8	<5			RB
5/19/86		<1				<1				USBR
6/11/86	1600	0.5								RB
11/21/86	1245	0.8	<5	<1	<1	<5	<5	<1		RB
12/17/86	940	0.5	<5	<1	<1	<5	<5	<1		RB
1/15/87	1015	1.4	<5	1	2	<5	<5	2		RB
2/20/87	840	0.3								RB
3/18/87	730	0.4	4.1	1	0.5	4	<1	6	3	RB
4/16/87	910	0.6								
5/13/87	1600	0.9								
6/16/87	1500	0.6								
11/19/87	1330	1.7								
12/15/87	900	0.2								
1/14/88	955	0.2								
3/23/88	900	0.3								
Minimum		0.2	<1	<1	0.5	<1	<1	<1		
Median		<0.5	1	1	2	7	<5	<1		
Maximum		1.7	7	8	10	26	9	6		
# Data		42	31	29	30	33	29	5		

Table A-48. Mineral Water Quality Data for Panoche-Silver Creek, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 38' 13", Longitude 120° 38' 21"
NE 1/4, SE 1/4, SE 1/4, Sec. 10, T.15S., R.12E.,
1/4 mi N of Panoche Rd, 1 mi W of I-5.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
5/22/30		2.0			2530	4.9	172	1070	142	114	364		0	317	317		2020	USGS
9/9/31		2.0			3000	6.5	202	1070	112	110	423		0	311	311		2070	USGS
1/9/52		4.0			5600	6.1	305	2210	299	212	700		0	382	382		3960	USGS
1/30/52		0.5			4300	4.8	170	1680	268	147	500		0	432	432		3030	USGS
3/19/52		5.0			2170	1.5	48	882	178	55	237		0	192	192		1520	USGS
1/28/53		0.5			3670	3.3	220	1330	183	143	442		0	434	434		2570	USGS
1/27/54		1.2			7600	8.6	460	2990	332	296	935		0	410	410		5250	USGS
1/26/56		33			1750	1.6	48	685	136	54	170		2	184	184		1210	USGS
3/19/57	1220	0.2		8.0	9340	13	720	4050	358	444	1440	14	0	550	550	2720	7320	USGS
2/10/58	1230	1.8		7.8	6830	6.1	364	3840	384	443	905	22	0	444	444	2780	6210	USGS
3/17/58		200			2020	1.5	42	753	133	74	179		0	200	200		1310	USGS
4/15/58	1150	26		7.8	2950	3.0	110	1402	34	278	314	9	0	408	408	1230	2370	USGS
4/22/59	1400	0.01		7.9	11600	23	1040	6450	474	735	2040	16	0	502	502	4210	11000	DWR
6/8/60	1600	0.01				20												DWR
2/27/62					5740	10	325	2920	224	419	760	10	14	408	422	2280	4890	DWR
4/3/63	1700	5.0		8.2	8400	13	615	4805	233	552	1400	14	0	320	320	2950	8080	DWR
3/14/84					6700	9.1												USBR
3/22/84	1530	0.3	73					3300	270	470	1100	11	0					RB
5/17/84	800		57		8400	10	510	2700	196	544	520	17.2	0	408	408			RB
5/25/84					9250	12												USBR
6/19/84					10500	15												USBR
7/27/84						16												USBR
8/22/84					12830	18												USBR
9/26/84					12200	18												USBR
10/15/84					11360	16												USBR
11/14/84					9230	14												USBR
12/12/84					9890	13												USBR
1/16/85					9270	12												USBR
2/11/85					9050	12												USBR

Table A-48 (continued). Mineral Water Quality Data for Panoche-Silver Creek, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 38' 13", Longitude 120° 38' 21"
NE 1/4, SE 1/4, SE 1/4, Sec. 10, T.15S., R.12E.,
1/4 mi N of Panoche Rd, 1 mi W of I-5.

DATE	TIME	FLOW	TEMP	pH	EC	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
		cfs	°F		(umhos/cm)	mg/L Total Recoverable												
3/11/85					8950	12												USBR
4/8/85					9340	13												USBR
5/6/85					11340	14												USBR
6/3/85					11120	15												USBR
12/12/85					10550	15												USBR
1/6/86					10240													USBR
2/15/86	1440			8.1	2200	1.9	60	1400	195	73	244	10.2	0	150	150	780	1800	RB
2/25/86	1615	1.0		9.0	4500	5.9	240	2400	199	319	540	13.2	0	400	400	1840	4000	RB
2/27/86					4820	6.0												USBR
3/13/86	830	12			2500	2.6	100	1200	168	126	288	7.9	0	240	240	880	2000	RB
5/19/86					11240	15												USBR
11/21/86	1500	1.0		8.1	10000	18	750	7600	600	920	2000	25.0	0	310	310	4400	12000	RB
12/17/86	1100	2.0		8.4	10000	19	800	6200	450	800	1400	19.0	0	220	220	3800	6500	RB
1/14/87	1540			8.2	10700	13	680	4700										RB
1/15/87	1100	4.0		7.7	10000		650	3700	380	720	1700	14.0				3500		RB
2/20/87	915	1.5		8.0	10000	14	360	2500					0					RB
3/18/87	900	2.0		8.1	10800	12.5	730											RB
4/16/87	1030	1.5		9.2	12000	17	770											RB
10/29/87	1000	25			3790	1.6	84	2220	472	116	362	24	0		127	1660	3730	RB
11/19/87	1445	0.8			12000	17	920	6200					0	480	480			RB
12/15/87	1615			8.1	11350	14	800	5100										RB
1/17/88	1200	85		7.9	4270	2.0	127	2380	412	170	496	17	0		125	1730	4160	RB
3/23/88	1000			8.4	11900	16	940	7200					<1	230	230			RB
Minimum					1750	1.5	42	685	34	54	170	7.9	0	150	150	780	1210	
Median					9250	12	345	2600	230	278	500	14	0	382	382	2700	3350	
Maximum					12000	23	1040	7600	600	920	2040	25	<1	550	550	4400	12000	
# Data					51	51	31	30	25	25	25	16	26	23	23	14	22	

Table A-49. Mineral Water Quality Data for Silver Creek, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 34' 47", Longitude 120° 40' 35"
NW 1/4, NW 1/4, SW 1/4, Sec. 31, T.15S., R.12E.,
6.5 mi W of I-5 on Panoche Rd.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
5/22/30		0.03			9950	8.8	528	4270	391	515	1090		0	348	348		6970	USGS
9/9/31		0.03			13000	13	918	5220	397	494	1820		0	290	290		9000	USGS
3/19/52		4			2620	2.6	68	1040	146	135	235		0	360	360		1820	USGS
1/28/53		2			7200	7.0	270	3090	227	397	790		0	396	396		5010	USGS
3/14/57	1230		68	8.3	6630	11	345	3590	210	448	930	15	0	216	216	2370	5680	DWR
1/7/59	1055	2		8.0	4950	7.8	222	2520	188	321	672	12	0	421	421	1790		DWR
7/6/59						20											9290	DWR
4/3/63	1630	5		8.1	5900	11	310	3293	158	423	938	13	0	412	412	2135	5350	DWR
3/22/84	1600	0.6	69		4600	7.6		2490	120	390	620	6.5						RB
12/17/85	1630			8.1	14000	23	1000	9100	518	1150	2210	36.5		700	700		16000	RB
1/15/86	1600			7.5	1000	20	940	7600					0	480	480			RB
2/25/86	1600	3.5		9.1	3600	4.5	120	1900	143	289	380	11.0	0	380	380	1480	3200	RB
4/25/86	1300	1.0		9.0	4000	5.1	130	2100		270	400	12.0	0	280	280	1620	3400	RB
1/15/87	1120	2.0		7.5	9100		400	3100	310	670	1300	17.0				3200		RB
2/20/87	940	3.0		8.0	7800	11	240	3000					0					RB
3/18/87	845	3.0		8.1	7500	10	370											RB
4/16/87	1050	0.5		9.1	9650	17	550											RB
11/19/87	1515				11800	18	870	6000					0	660	660			RB
12/15/87	1550			8.3	12100	18	900	5300										RB
1/14/88	1505			8.1	10900	16	670	4400										RB
3/23/88	1035			8.3	12100	19	1000	6800					<1	320	320			RB
Minimum					1000	2.6	68	1040	120	135	235	6.5	0	216	216	1480	1820	
Median					7650	11	380	3450	210	400	850	13.0	0	396	396	1965	5515	
Maximum					14000	23	1000	9100	518	1150	2210	36.5	<1	700	700	3200	16000	
# Data					20	20	17	18	11	12	12	8	13	13	13	6	10	

Table A-50. Mineral Water Quality Data for Cantua Creek, Fresno and San Benito Counties.

Sampling Location: NW 1/4, NW 1/4, Sec. 31, T.17S., R. 15E.
This creek is immediately south of the study area,
but is used for comparison purposes.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
1/8/52		0.5		8.7	1260	0.52	27	238	55	118	74	4.8	39	534	573	622	840	USGS
1/26/54					1400	0.74	29	337	79	121	82		0	584	584		957	USGS
5/2/55		1.1			1800	1.1	44	511	103	121	145		0	604	604		1250	USGS
1/25/56		40			440	0.30	2	72	26	33	25		2	204	206		286	USGS
3/19/57	1410	0.6		8.5	1880	1.1	58	485	30	184	163	6.2	34	634	703	830	1280	USGS
2/7/58	1100	3.5		8.5	1200	0.94	26	204	29	128	68	3.5	28	556	613	600	776	USGS
3/17/58		100			1150	0.37	18	298	55	87	86		14	386	400		772	USGS
4/15/58	630	33		8.0	1610	0.65	30	538	29	155	130	4.4	0	482	482	710	1150	USGS
6/3/58	900	3		8.4	1690	1.1	40	492	18	168	138	4.0	16	556	588	736	1170	DWR
11/13/58	900	0.3		8.2	3480	2.4	126	1350	112	288	377	6.4	0	815	815	1460	2690	DWR
1/7/59	910	2		8.3	2190	1.3	46	831	86	153	222	7.5	12	497	522	418	1620	DWR
2/2/60	1340	5.0		8.5	922	0.59	16	163	20	96	52	2.5	15	404	434	444	582	DWR
1/26/61	1515	15		7.6	101	0.08												DWR
3/23/62	730	3		8.2	1515	0.65	44	486	14	159	130	10	0	510	510	689	1100	DWR
4/3/63	1800	3		8.9	2000	1.4	55	659	96	153	193	5.3	57	445	500	777	1610	DWR
1/23/64	730	20		8.3	1500	0.80		471			142						1010	DWR
12/6/66	1500			8.3	418		3.7		35		14		0	191	191	183		DWR
5/28/71	915			9.0	1890	1.6	50		32		208		45	470	515	749		DWR
2/15/73	1300	14		8.0	1290	0.60	19		40	113	89		0	496	496	566		DWR
1/24/78	1015	3		8.4	1470	0.80	30	347	35	148	91	3.6	34	529	563	695	1030	DWR
Minimum					101	0.08	2	72	14	33	14	2.5	0	191	191	183	286	
Median					1500	0.78	30	485	35	148	130	5.0	14	510	510	695	1150	
Maximum					3480	2.4	126	1350	112	288	377	10	57	815	815	1460	2690	
# Data					21	20	19	17	19	17	20	16	19	19	19	15	17	

Table A-51. Mineral Water Quality Data for Los Gatos Creek Above Nunez Canyon, Fresno County.

Sampling Location: SW 1/4, SW 1/4, Sec. 28, T.20S., R.14E. at USGS gauge. This creek is immediately south of the study area, but is used for comparison purposes.

DATE	TIME	FLOW cfs	TEMP °F	pH	EC (umhos/cm)	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	TALK	HDNS	TDS	Sampler
						mg/L Total Recoverable												
1/8/52		1			1200	0.37	52	160	28	128	83		55	544	599		791	USGS
3/7/52					1100	0.78	56	224	38	64	124		0	380	380		710	USGS
1/28/53		0.7			2350	1.6	165	470	24	136	332		45	674	719		1530	USGS
1/26/54		0.1			1500	0.56	58	250	30	151	109		47	614	661		963	USGS
1/25/56		375			420	0.29	9	51	19	33	32		17	191	208		273	USGS
3/14/56	1630			7.8	1960	1.2	87	471	9.1	170	206	4.9	0	684	684	722	1290	DWR
3/14/57	1600			8.2	2000	1.0	89	469	21	174	191	13	0	707	707	768	1320	DWR
3/20/57	835	0.6		8.6	1890	0.95	82	461	23	164	192	4.0	33	605	672	733	1260	USGS
2/7/58	900	3.6		8.9	1410	0.63	68	207	20	168	96	5.2	73	588	736	700	921	USGS
4/14/58	1425	7.7		8.0	1330	0.67	50	392	22	101	139	4.3	0	352	352	470	910	USGS
1/6/59	1830	4		8.4	1240	0.89	50	308	64	54	141	6.4	8	334	350	380	812	DWR
2/2/60	1455	8		8.2	952	0.77	33	258	60	33	102	3.5	0	236	236	285	623	DWR
12/20/62	815	2		8.6	2190	1.2	83	741	42	160	262	4.1	33	518	550	762	1720	DWR
12/6/66	1700			8.4	579		7.8		47		25		5	312	320	259		DWR
2/15/73	1200	12		8.0	1400	0.80	38		43	91	136		0	403	403	481		DWR
1/24/78	1100	15		8.3	1710	0.90	57	495	40	127	167	4.9	0	483	483	621	1200	DWR
4/16/87					2300	1.4			34	170						784		RB
Minimum					420	0.29	7.8	51	9.1	33	25	3.5	0	191	208	259	273	
Median					1410	0.89	58	392	32	128	139	4.9	8	518	515	660	963	
Maximum					2350	1.6	165	741	64	174	332	13	73	707	736	784	1720	
# Data					17	16	16	14	17	16	16	9	16	16	16	12	14	

Table A-52 Total Recoverable Trace Element Water Quality Data for Panoche-Silver Creek, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 38' 13", Longitude 120° 38' 21"
NE 1/4, SE 1/4, SE 1/4, Sec. 10, T.15S., R.12E.,
1/4 mi N of Panoche Rd, 1 mi W of I-5.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	Sampler
		µg/L Total Recoverable								
3/14/84		6	9	9	7	16	3			USBR
3/22/84	1530	6.0								USBR
5/25/84		6.0	18	3	2	23	<1			USBR
6/19/84		6.0	15	5	<1	13	<1			USBR
7/27/84		2.0	8			23	<1			USBR
8/22/84		2.0	2		1	<1	2			USBR
9/26/84		3.0	8	2	4	7	1			USBR
10/15/84		3.0	13	4	2	26	2			USBR
11/14/84		4.0	4	3	1	11	<1			USBR
12/12/84		5.0	7	8	3	30	<1			USBR
1/16/85		5.0	9	2	2	25	<1			USBR
2/11/85		5.0	5	1	3	15	1			USBR
3/11/85		3.0	7	2	<2	15	2			USBR
4/8/85		2.0	3	<1	<2	15	6			USBR
5/6/85		<1	3	4	7	24	<1			USBR
6/3/85		<1	7	1	<1	13	3			USBR
12/12/85		2.0	7	5	4	7	2			USBR
1/6/86		2.0	4	2		12				USBR
*2/15/86	1440	17	13	420	7000	2300	8			RB
2/25/86	1615	10	11	20	36	89	<5			RB
2/27/86		10	8	9		29				USBR
*3/13/86	830	23	12	140	53	280	11			RB
5/19/86		3	8	<4		16				USBR
11/21/86	1500	2.1	<5	<1	<1	<5	<5	<1		RB
12/17/86	1100	2.0	17	<1	<1	<5	<5	<1		RB
1/15/87	1100	2.6	9	8	2	13	<5	2		RB
2/20/87	915	2.3								RB
3/18/87	900	1.9	11	<5	2.1	34	<1	9	39	RB
4/16/87	1030	2.4								RB
11/19/87	1445	2.8								RB
12/15/87	1615	2.6								RB
1/14/87	1540	2.5								RB
3/23/88	1000	4.1								
Minimum		<1	2	<1	<1	<1	<1	<1		
Median		3	8	4	2.1	20	2	2		
Maximum		10	18	20	36	89	8	9		
# Data		33	28	26	24	28	23	6		

*High flow/sediment - not considered in data analysis.

Table A-53 Total Recoverable Trace Element Water Quality Data for Silver Creek, Fresno and San Benito Counties.

Sampling Location: Latitude 36° 34' 47", Longitude 120° 40' 35"
NW 1/4, NW 1/4, SW 1/4, Sec. 31, T.15S, R.12E,
6.5 mi W of I-5 on Panoche Rd.

DATE	TIME	Se	Mo	Cu	Cr	Ni	Pb	Zn	U
		µg/L Total Recoverable							
3/22/84	1600	4.0							
12/17/85	1630	18	14	9	4	120	10		
1/15/86	1600	3.0	15	8	5	47	12		
2/25/86	1600	10	14	21	18	55	<5		
4/25/86	1300	8.0	9	9	2	11	<5		
5/15/86	815	5.0	<5	3	2	13	<5		
1/15/87	1120	11	9	6	3	23	<5	7	
2/20/87	940	8.6							
3/18/87	845	5.4	9.6	<5	6.1	24	<1	14	27
4/16/87	1050	2.0							
11/19/87	1515	1.7							
12/15/87	1550	2.2							
1/14/88	1505	3.2							
3/23/88	1035	6.4							
Minimum		1.7	<5	3	2	11	<1		
Median		7.5	9.6	8	4	24	<5		
Maximum		18	15	21	18	120	12		
# Data		14	7	7	7	7	7		

APPENDIX B

PRECIPITATIONS

VOLUME CALCULATIONS

COMPUTATION OF RUNOFF VOLUMES FROM PRECIPITATION DATA

The procedure used to estimate the runoff volume for individual watersheds in the study area was as follows:

First, isohyetal lines from the Department of Water Resources' 50-year average annual precipitation maps were transferred to 1:100,000 scale maps with watershed boundary lines. Second, the total precipitation volume incident on each watershed was determined by the "method of averages." With this technique, the area of influence of each isohyetal line extends one-half the distance to the next adjacent line on both sides of the isohyetal. The area between each pair of average lines was then found by use of a planimeter. Since the accuracy of the planimeter is variable, each area was planimetered at least three times to obtain an average value. The planimeter readings are unitless, but were divided by ticks per square miles to obtain areas in square miles. The volume of precipitation per area was computed by the following equation:

$$\frac{(mi^2 \text{ area})(\text{inches precip.}) * (640 \text{ acres}/mi^2)}{12 \text{ inches}/ft} = \text{acre-ft water}$$

Individual volumes were added together to give the total volume of precipitation per watershed. The average precipitation volume for each isohyetal line in the watersheds is given in Table B-1.

The final step is to derive the runoff volumes from the volumes of precipitation calculated to fall on the watershed. Stream flow data are only available for a limited number of creeks in the study area (Table 5-7). Using this measured streamflow data and the computed average precipitation volume that falls on the watershed, an estimate of the percent of runoff can be obtained. The method used for each gauged watershed is to divide the published streamflow by the computed precipitation volume. It should be recognized that the yield factors can only be estimated by this method because it is assumed that uniformed conditions exist in the basin.

For the measured watersheds, the area upstream of the flow measurement station is often different from the area of the watershed as defined in this study. Most of the measured creeks had additional watershed downstream of the measurement point. Where they were not identical, the streamflow volume was adjusted by a factor defined by:

$$\frac{\text{Gauged area}}{\text{Study Area}} = \text{Adjustment Factor}$$

The runoff percentages calculated from the adjusted streamflow volume were used to calculate runoff for the unmeasured watersheds.

Table B-1. Annual Precipitation Volumes Estimated From 50-Year Average-Annual Rainfall Isohetal Lines for Creeks in the Eastern Drainage of the Diablo Range.

Watershed Name (Number)	Total Drainage Area	Rainfall (inches)	Area (sq. mi)	Precipitation (AF)
Sand (1)	11	20	1.45	1,550
		18	1.84	1,765
		16	1.06	905
		15	1.52	1,215
		14	2.52	1,880
		13	2.71	1,880
		Totals	11.10	9,195
Deer Valley Creek (2)	5	18	0.32	310
		16	1.39	1,185
		15	1.58	1,265
		14	1.29	965
		13	0.52	360
		Totals	5.10	4,085
Briones Valley Creek (3)	7.5	13	0.50	350
		14	1.70	1,270
		15	3.70	2,950
		16	0.90	770
		17	0.60	540
		18	0.60	570
		19	0.40	400
		20	0.40	420
		Totals	8.80	7,270
Marsh Creek (4)	42.6	26	7.00	9,705
		24	4.13	5,285
		22	4.80	5,630
		20	6.68	7,125
		18	8.22	7,890
		16	4.77	4,070
		15	5.74	4,590
		14	3.65	2,725
		13	0.61	425
		Totals	45.60	47,445
Kellogg Creek (5)	20	16	6.19	5,280
		15	11.61	9,290
		14	4.84	3,615
		13	2.90	2,010
		Totals	25.54	20,195
Unnamed (6)	5.2	12	1.60	1,025
		13	2.30	1,595
		14	1.30	970
		Totals	5.20	3,590
Brushy Creek (7)	14.6	12	0.90	580
		13	4.80	3,360

Table B-1 cont. Annual Precipitation Volumes Estimated From 50-Year Average-Annual Rainfall Isohetal Lines for Creeks in the Eastern Drainage of the Diablo Range.

Watershed Name (Number)	Total Drainage Area	Rainfall (inches)	Area (sq. mi)	Precipitation (AF)
		14	6.70	5,015
		15	2.20	1,735
		Totals	14.60	10,690
Bethany Reservoir Area (8)	12.9	12	1.40	890
		13	10.20	7,050
		14	1.30	970
		Totals	12.90	8,910
Mountain House Creek (9)	11.6	11	1.16	680
		12	6.54	4,185
		13	3.48	2,410
		Totals	11.18	7,275
Patterson Run Creek (10)	18	9	2.40	1,150
		10	5.90	3,145
		11	6.80	3,990
		12	2.90	1,855
		Totals	18.00	10,140
Corral Hollow Creek (11)	65.2	20	1.16	1,235
		18	3.68	3,535
		16	5.93	5,060
		15	6.80	5,440
		14	1.97	1,470
		13	4.23	2,935
		12	7.71	4,935
		11	11.23	6,590
		10	15.68	8,365
		9	5.55	2,665
		8	1.26	540
		Totals	65.20	42,770
Deep Gulch Creek (12)	15.8	10	1.68	895
		9	5.19	2,490
		8	8.97	3,825
		Totals	15.84	7,210
Lone Tree Creek (13)	22.6	16	0.23	195
		15	1.19	950
		14	4.00	2,985
		13	3.77	2,615
		12	3.26	2,085
		11	3.10	1,820
		10	3.42	1,825
		9	1.26	605
		8	2.39	1,020
		Totals	22.62	14,100

Table B-1 cont. Annual Precipitation Volumes Estimated From 50-Year Average-Annual Rainfall Isohetal Lines for Creeks in the Eastern Drainage of the Diablo Range.

Watershed Name (Number)	Total Drainage Area	Rainfall (inches)	Area (sq. mi)	Precipitation (AF)
Hospital Creek (14)	36.2	18	0.81	780
		16	3.00	2,560
		15	3.84	3,070
		14	4.71	3,515
		13	5.13	3,555
		12	5.74	3,675
		11	6.00	3,520
		10	3.39	1,810
		9	1.55	745
		8	2.06	880
		Totals	36.23	24,110
Arkansas-Martin Creek Area (15)	12	10	2.13	1,136
		9	7.03	3,374
		8	2.84	1,212
		Totals	12.00	5,722
Ingram Creek (16)	20.4	12	1.32	845
		11	8.06	4,729
		10	11.00	5,867
		Totals	20.38	11,440
Mile 33 Creek (17)	1.6	10	1.58	845
Kern Creek (18)	6.1	10	13.00	3,270
Del Puerto Creek (19)	76.2	17	12.61	11,435
		16	8.71	7,435
		15	5.81	4,650
		14	9.06	6,765
		13	10.93	7,580
		12	9.10	5,825
		11	6.42	3,765
		10	13.52	7,210
		Totals	76.16	54,665
Black Gulch Creek (20)	3	10	2.97	1,585
Unnamed Creek (21)	3.7	10	3.74	1,995
Salado Creek (22)	25.6	14	0.64	480
		13	7.13	4,945
		12	6.03	3,860
		11	3.13	1,835
		10	8.71	4,645
		Totals	25.64	15,765
Little Salado (23)	9.1	11	1.55	910
		10	8.52	4,545
		Totals	10.07	5,455

Table B-1 cont. Annual Precipitation Volumes Estimated From 50-Year Average-Annual Rainfall Isohetal Lines for Creeks in the Eastern Drainage of the Diablo Range.

Watershed Name (Number)	Total Drainage Area	Rainfall (inches)	Area (sq. mi)	Precipitation (AF)
Crow Creek (24)	28.4	14	2.35	1,755
		13	5.97	4,140
		12	6.71	42,945
		11	3.93	2,305
		10	9.48	5,055
		Totals	28.44	56,200
Interfan Creeks (25)	4	8.5	4.00	1,810
Orestimba Creek (26)	141	18	40.09	38,485
		17	23.71	21,500
		16	16.01	13,660
		15	12.97	10,375
		14	9.81	7,325
		13	10.74	7,445
		12	13.29	8,505
		11	13.90	8,155
		10	0.50	265
		Totals	141.02	115,715
Bennet Valley Creek (27)	6	10	6.00	3,200
Garzas Creek (28)	57.3	17	10.93	9,910
		16	10.06	8,585
		15	3.71	2,970
		14	4.42	3,300
		13	7.87	5,455
		12	11.03	7,060
		11	9.32	5,470
		Totals	57.34	42,750
Mustang Creek (29)	8	10	7.60	4,055
		11	0.40	235
		Totals	8.00	4,290
Quinto Creek (30)	31.6	16	3.06	2,610
		15	3.43	2,745
		14	3.00	2,240
		13	4.26	2,955
		12	5.06	3,240
		11	3.55	2,085
		10	9.29	4,955
		Totals	31.65	20,830
Romero Creek (31)	24.1	15	2.58	2,065
		14	5.00	3,735
		13	4.35	3,015
		12	2.35	1,505
		11	1.58	925

Table B-1 cont. Annual Precipitation Volumes Estimated From 50-Year Average-Annual Rainfall Isohetal Lines for Creeks in the Eastern Drainage of the Diablo Range.

Watershed Name (Number)	Total Drainage Area	Rainfall (inches)	Area (sq. mi)	Precipitation (AF)
		10	8.29	4,420
		Totals	24.15	15,665
Los Banos Creek (32)	156	22	16.90	19,830
		20	23.39	24,950
		18	27.68	26,570
		16	19.55	16,680
		14	17.45	13,030
		12	20.10	12,865
		10	15.71	8,380
		9	7.87	3,780
		Totals	148.65	126,085
Salt Creek (33)	21.2	10	0.32	170
		9	10.29	4,940
		8	10.55	4,500
		Totals	21.16	9,610
Ortigalita Creek (34)	56.3	18	0.58	555
		16	4.90	4,180
		14	7.74	5,780
		12	6.77	4,335
		10	9.52	5,080
		9	9.61	4,615
		8	17.19	7,335
		Totals	56.31	31,880
Unnamed Creeks (35)	12.9	8	12.90	5,505
Laguna Seca Creek (36)	7.1	8	7.45	3,180
Wildcat Canyon Creek (37)	32	8	32.03	13,665
Little Panoche Creek (38)	90	18	0.74	710
		16	8.94	7,630
		14	10.39	7,760
		12	8.00	5,120
		10	15.39	8,210
		9	32.48	15,590
		8	13.39	5,715
		Totals	89.33	50,735
Moreno Gulch-Panoche Hills (39)	70	9	8.71	4,180
		8	61.68	26,315
		Totals	70.39	30,495
Panoche-Silver Creek (40)	275	22	20.10	23,585
		20	19.77	21,090
		18	41.35	39,695
		16	33.33	28,440

Table B-1 cont. Annual Precipitation Volumes Estimated From 50-Year Average-Annual Rainfall Isohetal Lines for Creeks in the Eastern Drainage of the Diablo Range.

Watershed Name (Number)	Total Drainage Area	Rainfall (inches)	Area (sq. mi)	Precipitation (AF)
		14	31.03	23,170
		12	25.71	16,455
		10	42.51	22,670
		9	37.03	17,775
		8	22.58	9,635
		Totals	273.41	202,515